

The AMSAT[®] Journal

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Keith Baker, KB1SF congratulates Martha Saragovitz on her 25 years of service to AMSAT

Space Symposium XX Comes to Fort Worth

Over 200 AMSAT-NA members and satellite enthusiasts, including a sizeable international contingent, met in Fort Worth, Texas, November 7-11, 2002 at the 20th Space Symposium and AMSAT-NA annual meeting. Among other activities, attendees chronicled recent and future amateur radio satellite technology developments. The Lockheed-Martin Amateur Radio Club coordinated the event and its members were commended and congratulated for their excellent organization and warm welcome.

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The AMSAT Journal staff is always interested in article submissions. Whenever possible, text should be on IBM compatible diskettes with hardcopy or original photographs or figures. AMSAT-NA reserves the right to select material for The AMSAT Journal based on suitability of content and space considerations. The editors of this publications are volunteers giving freely of their talents, time, and efforts to produce The AMSAT Journal.

Apogee View

For The Greater Good

In these pages, and via our ANS bulletins, much has been said about AMSAT-NA's two newest projects, Eagle and Echo. Unfortunately, far less coverage has been given lately to an equally exciting project that has been ongoing for many, many years. In fact, if the truth be known, this project has provided a powerful and very useful tool for Amateur Radio as a whole to justify our continuing access to the literally billions of dollars worth of real estate. This real estate is otherwise known as our "operating frequencies".

For, perhaps nowhere else is AMSAT and Amateur Radio more visible to those not immediately familiar with what we do than via our work with the Amateur Radio on the International Space Station (ARISS) project. ARISS represents the latest melding of volunteer teams that pioneered development and use of Amateur Radio equipment on human-tended spaceflight vehicles.

As many of you may recall, the Shuttle/Space Amateur Radio Experiment (SAREX) team enabled Owen Garriot, W5LFL, to become the first astronaut ham to use Amateur Radio from space. Thanks to the initiative of AMSAT and ARRL as well as the cooperation of NASA, that happened way back in 1983 on STS-9. SAREX would later become the most "frequent flier" payload carried aboard the Shuttle. It provided thousands of school children from around the world with a once-in-a-lifetime opportunity to share a few moments "voice to voice" with an astronaut...in orbit...around our Earth.

Later, Amateur Radio equipment carried aboard the MIR space station continued this lofty tradition by again bringing school children into direct contact with astronauts in orbit. But this time, there was an added twist. This time, some of the astronauts they spoke with were from another country. Most were flying on a space vehicle launched from that "other country". They also learned about the many benefits of international cooperation in space, and that when otherwise hostile countries can find ways to work together, really great things can happen. Through these brief, but nevertheless very powerful personal exchanges, a growing number of school children also learned that, when viewed from space, our Earth really *doesn't* have political boundaries!

In addition, NASA learned a lesson that we hams have known for years...that Amateur Radio can provide a wonderful morale boost for people stationed in remote areas (Space) by helping them keep in touch with other human beings back in civilization (Earth). This fact became the basis of NASA's invitation for Amateur Radio to again fly on the International Space Station. But, this time, it would go along as "crew equipment". For, not only would the great benefits of talking to school children continue on the ISS, but the crews would now have a permanently installed way to keep in touch with their families and the rest of humanity via Amateur Radio during their long days, weeks and months in orbit.

By any measure, these are great things. And AMSAT has been right in the middle of making them happen from the very beginning. For it's been an international team made up largely of AMSAT people who've planned for, built and then tested the Amateur Radio equipment that's been carried aboard these human spaceflight vehicles.

Far from being just another satellite that AMSAT prepares for launch, every single ARISS item, from the actual radio components right down to the connector plugs, micro-phone cords and interconnecting cables have to be built, tested, re-tested, and then certified to be proven safe for the human ISS crew. Documentation on how the crew interacts with the equipment must also be drafted and then approved. This all spells "paperwork", and there's been, quite literally, a *ton* of it generated by ARISS and its predecessors. I've been told that the weight of the paperwork to justify flying something on a human-tended vehicle often exceeds the weight of the item itself...usually by a factor of at least 10 or more!

Yet, despite these noble efforts, most of the general public still thinks Amateur Radio is CB. Fewer still have any idea that anyone else (besides a government space agency or a large commercial contractor) has the wherewithal to build, (let alone to actually launch or use!) communications equipment into space. So, in that sense, most of what we do in AMSAT remains *way* below the public's radar screen. However, I've often found that when many of those same non-hams are asked if they have ever seen the astronauts chatting with school children from space via Amateur Radio, their eyes

[Continued on Page 31]

Symposium XX

[continued from page 1]

In addition to a full lineup of excellent speakers and technical presentations, the Symposium activities also featured:

- The AMSAT Store (and attached swap area);
- A fully equipped antenna test range for antenna gain measurement by Kent Britain, WA5VJB;
- A test bench equipped for noise figure measurement by Al Ward, W5LUA;
- The *Satellites in Education Program* by the AMSAT Education Staff;
- An electronic surplus stores tour;
- A Field Operations breakfast;
- The annual AMSAT meeting;
- Saturday evening banquet featuring keynote speaker Chris Imlay, General Counsel of the ARRL;
- A tour of Fort Worth's Lockheed-Martin Aeronautics Company to see the final assembly and systems integration facilities of the F-16 jet fighter.

AMSAT members were also welcome to attend the AMSAT Board of Directors Meeting on November 10-11.

The papers presented in the Space Symposium were very good and AMSAT takes this opportunity to thank the authors and presenters. Copies of the proceedings can be obtained from Martha at the AMSAT Office.

The complete lineup of technical presentations were as follows:

- *AO-7 Status Report*, Mike Seguin, N1JEZ
- *Turkey's First LEO Small Satellite*, Ali Telli
- *Environmental Factors Affecting AO-40 Reception*, G. Gould Smith, WA4SXM
- *A Disposable Antenna for Receiving AO-40 on S-Band*, Anthony Monteiro, AA2TX
- *The VSA: Thinking Big on a Small Scale*, Dr. H. Paul Shuch
- *How Kids Can Talk to Space People (Who are aboard the International Space Station)*, Gene Chapline, K5YFL
- *The P5 Special: A Satellite Station*

for North Korea, Bruce Paige, KK5DO

- *Experiences in Getting a Mode-S System Working and Tested: Using the Sun to Verify its Performance*, Nick Pugh, K5QXJ
- *Dual-Band Dish Feeds for 13/23 cm*, Gerald Brown, K5OE
- *AMSAT OSCAR-E Project Status Update*, Richard Hambly, W2GPS
- *So You Want to Build a Satellite! – Revisited*, Dick Jansson, WD4FAB
- *Microsat Design - What Do People Want?*, Richard Hambly, W2GPS
- *Eagle Operational Changes*, Project Eagle Staff
- *ARISS Status Report*, Frank Bauer, KA3HDO
- *AO-40 RUDAK Description and Results*, AO-40 RUDAK Team
- *Proposal for a FEC-Coded AO-40 Telemetry Link*, Phil Karn, KA9Q

- *Making a Case for Amateur Spectrum Through Research, Education, and Industry Cooperation*, Cliff Buttschardt, K7RR; W6HDO; and Clark Savage Turner, WA3JPG

The AMSAT Educational program also welcomed a group of sixth graders from Dallas' DeGolyer School. The school is one of the prototypes of the ARRL's "Big Project" schools, and most of the participating kids are now licensed. The students had a great time building disposable antennas from cardboard boxes and aluminum foil, using the design provided by Tony Monteiro, AA2TX. Another hands-on project, led by the education team headed by Sanlyn Kent featured a Yagi antenna designed by Tony & Kent Britain.

The new "Presidents Club Core" donor program was introduced with 35 new



2002 Symposium Participants hear the latest news of amateur satellite technology at Fort Worth, Texas

- *A K-Band Receiver for AO-40 (For Less Than a King's Ransom)*, Gerald Brown, K5OE

Additional papers which were published in the Symposium Proceedings included:

- *RUDAK DSP – Software Defined Radio in Space*, Assi Friedman, 4X1KX/KK7KK; Jim White, WD0E; Michael Kingery, KE4AZN; Lyle Johnson, KK7P; Harold Price, NK6K, and Chuck Green, N0ADI.

members at this level, plus additional members at the existing Bronze, Silver and Gold levels. Our fund-raising objective is to have a large majority of AMSAT-NA members at one of the four donor levels, depending on their capabilities to contribute to ongoing AMSAT efforts. Tax receipts are available for USA members.

An EAGLE technical meeting took place on Sunday, November 10. Many design items were discussed with co-ordination between Eagle and the AMSAT-DL P3E program being a major topic. It seems that there are

several items in common between these two satellites (such as the IHU), and though the primary mission objectives for each of the birds may differ, we anticipate a significant amount of cooperation between the satellites' design teams.

The keynote speaker at the Saturday evening banquet was Chris Imlay, W3KD, general counsel for the American Radio Relay League. Chris talked about the problems of frequency preservation between 1.0 and 10.0 GHz and noted that all of these frequencies are under attack from commercial interests. However, he concluded that it is primarily for amateur satellite usage that these frequencies are being preserved by the FCC (and other national bodies). Without the efforts of AMSAT and its members, the S,C, and X bands would probably no longer exist for amateur use. In an earlier meeting with AMSAT officers and board members, Imlay and Walter Ireland, from the ARRL, discussed frequency preservation, education at the university level, and the need for maintaining a close working relationship between AMSAT and ARRL.



Chris Imlay, W3KD, ARRL General Counsel

Robin Haighton, President AMSAT-NA, extended his thanks on behalf of the membership and the Board of Directors to the following retiring Officers of AMSAT-NA:

- Keith Baker, KB1SF, who stepped in as Executive Vice-President during 2002 and was a wonderful support and help during the year. Keith remains on the Board of Directors and is the Immediate Past President.
- Keith Pugh, W5IU, retiring from Vice President of Operations after seven years of work; many thanks, Keith, for a great effort. Keith will continue to co-ordinate the AMSAT-NA nets.
- Steve Bible, N7HPR, retiring from VP Educational Liaison (since 1998); thank you Steve for developing this Vice Presidency and getting the ball rolling.

Robin also welcomed Rick Hambly, W2GPS as Executive Vice President, Stacey Mills, W4SM as VP Operations and JoAnne Maenpaa, WB9JEJ as AMSAT Journal Editor. ■



(above and below) Keith Pugh, W5IU, 2002 Symposium Chairman



Former AMSAT Board of Directors Member Harry Yoneda, JAIANG, and his wife with daughter, Yuri

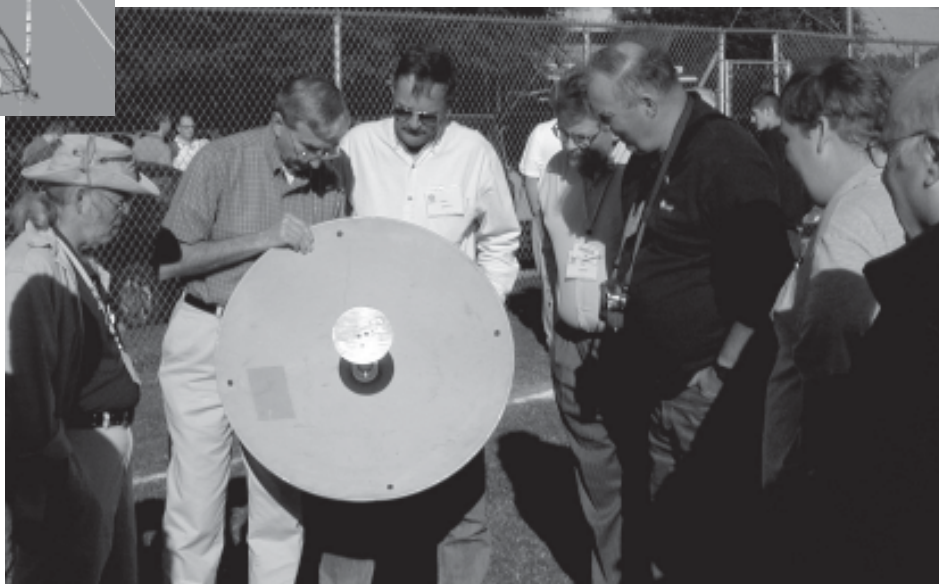
Symposium Technical Forums



The Lockheed-Martin club station W5SJZ was available for satellite operations.



Tony Monteiro AA2TX tests his 'disposable antenna' on the test range



Measuring the gain of a 3' dish with a patch feed



(above) Home on the Range ... getting the test gear set up for the antenna measurement range



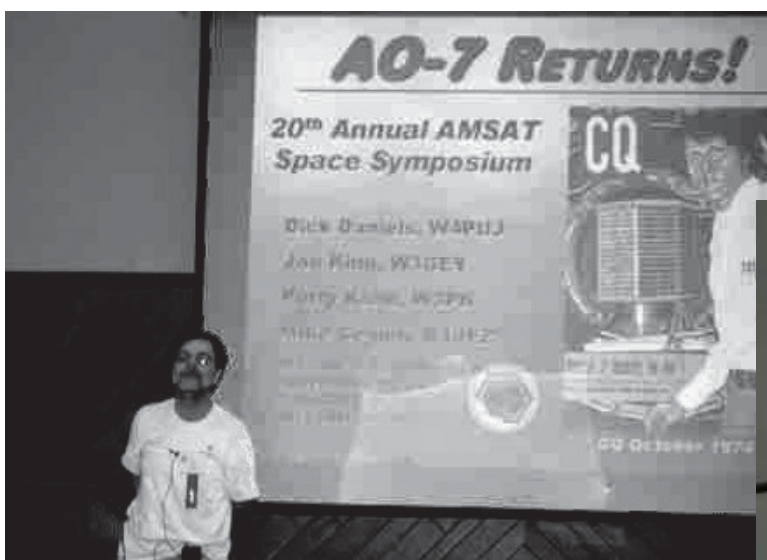
(left) Al Ward, W5LUA with his noise figure measurement gear for getting the real numbers on pre-amps and downconverters.

Satellite Design and Operations Seminars Provided an Opportunity to Hear from the Experts



(left) Bdale Garbee, KB0G, discusses RUDAK operations on AO-40.

(right) Tony Monteiro, AA2TX, shown during his talk, "A Disposable Antenna for Receiving AO-40 on S-Band."



(above) AO-7 Control Operator Mike Seguin, N1JEZ talked about AO-7's return to life.

(below) Dr. H. Paul Shuch, from SETI talked about an antenna array, "The VSA: Thinking Big on a Small Scale".



Banquet Grand Prize Winner Gordon Felder, W6DCP



Yuri Yoneda (L) and Ray Hoad, WA5QGD (R), shown presenting Gordon Felder W6DCP (center), with the Grand Prize, an ICOM IC910H, multiband, all mode transceiver.

AMSAT thanks our 2002 Prize Donors!

2002 Symposium Prize Donor List					
ICOM America, Inc.	ICOM IC910H multiband, all mode transceiver	Buckmaster	Ham Call CD	NEMAL Electronics	\$25 Gift Certificate
Bird Electronic Comany	Model 43 Thruline RF watt meter	DCI, Digital Communications, Inc.	DCI 146-4H 2M bandpass filter	SETI League, Inc.	2 - 1 year memberships to SETI
American Radio Relay League	2003 Handbook	G4IDE	2 - UI-View packet radio software	The Daily DX	2 - 1 year subscriptions to The Daily DX
	Satellite Handbook	IIX Equipment LTD	SO2 Standoff Bracket	Worldradio, Inc.	6 - 1 year subscriptions to Worldradio
	Satellite Anthology Book	Mini-Circuits, Inc.	ZRL-2300 Amplifier	NorTex Electronics	\$50 Gift Certificate
	UHF Microwave Projects, Vol. 1&2		PM-542 K1-HAT RF attenuator pads	CQ VHF Magazine	2 - 1 year subscriptions to CQ VHF
	1 year subscription to QEX		ZNBT-60-1W Bias Tee	Jim Berry - Pocketsat	2 copies of Pocketsat plus
	ARRL cap		ZSWA-4-30DR RF switch and driver		

The Grand Prize winner of the ICOM IC910H Multiband All mode Transceiver was Gordon Felder, W6DCP. Edward Rojowski, N8GZL and Gerald C. Chaisson, W5VUY won the UI-View. The winners of Pocketsat + are: Frank Bauer, KA3HDO, and James Dugal, N5KNX. We also wish to thank Yuri Yoneda, daughter of Haruo (Harry) Yoneda, JA1ANG for her capable aid as the drawer of the prize tickets. ■

2002 Symposium Awards



Thank-you to everyone who helped to make the AMSAT 2002 Space Symposium and Annual Meeting a success!

Congratulations everyone ...

2002 Symposium Recognition Awards					
Stacey Mills	W4SM	Nill Penny	WM5U	Rick Hambly	W2GPS
Mike Seguin (2)	N1JEZ	Charles Gunter	KD5MHC	Steve Thompson	K5PK
Jim White	WD0E	Doug Howard	KG5OA	Steve Bible	N7HPR
Bdale Garbee	KB0G	Bob Stricklin	N5BRG	Gould Smith	WA4SXM
Lyle Johnson	KK7P	Harold Reasoner	K5SXX	Bob Carpenter	W3OTC
Chuck Green	N0ADI	Jody Reasoner		Bill Hook	W3QBC
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Kent Britain	WA5VJB	Ray Hoad	WA5QGD	Andrerw MacAllister	W5ACM
Al Ward	W5LUA	Keith Pugh	W5IU	Larry Westmorland	K5PHD
Tommy Davis	W5TCD	Huntsville ARC	K4BFT	Larry Brown	W7LB
Melinda Davis		Robert Seydler Jr	K5GNA		

AMSAT Journal Telemetry

New Amateur Satellite Payload on RS-20

The Amateur Radio satellite community received news from Russia, via an e-mail message to AMSAT from Alexander N. Zaitzev announcing the launch of a new amateur satellite.

Alexander's message said, "At November 28, 2002 at 09:41 Moscow time from Plesetsk were launched two satellites - Algerian AlSat-1 and Russian "Mozhaetz" circa RS-20! Please listen for RS-20 at 435.319 MHz and 145.828 MHz. The telemetry signal format almost the same as RS-21 (Kolibri-2000)."

Any reports are appreciated via e-mail to plis@kaluga.ru and zaitzev@izmiran.rssi.ru.

Not much was heard from RS-20 for the first couple of days. Then signal reports began to appear from around the world. Mineo Wakita JE9PEL reported:

I heard good CW signal of RS-20 by using ALSAT-1 keps on 435.3185MHz +/- doppler, every approximately 15 second, at 23:09:00-23:22:00 UTC, 1 Dec 2002. Recordings of RS-20 are at:

wav 2322 KB <http://www.ne.jp/asahi/hamradio/je9pel/21202r20.wav>

mp3 527 KB <http://www.ne.jp/asahi/hamradio/je9pel/21202r20.mp3>

Don Woodward KD4APP wrote, "I just heard RS-20 at 0214 UTC (Tuesday December 3, 2002) on a very low pass (maximum 3 degrees). It was very loud. Sounded like random CW - I have posted a MP3 file on my satellite sounds page on my website. <http://kd4app.webhop.org>"

Ib Christoffersen OZ1MY said, "During this pass with AOS at 2014 UTC on 1 December, the new Russian satellite was heard again.

Again this time on 70 cm (435.319 MHz). The downlink signal looked like telemetry - but I can not read that. The satellite was in easy reach of Moscow. Therefore I think they were uplinking and downlinking to/from the satellite. The keps for Alsat-1 seems to be correct for the new one (Mozhayets)."

Discovering an additional mode besides the announced CW telemetry, some thought that the new telemetry on the Russian Mozhaetz satellite sounded like two tone FSK, 1200 and 2400 hertz. Howard G6LVB thought that the MixW2 software could be used to decode the FSK signal. He suggested to try the following:

1. First set to RTTY mode and check that it works OK.
2. In the Mode -> Mode Settings menu.
 - a. Set the RX frequency to 1800;
 - b. Over-key the Shift to 1200;
 - c. Over-key the baud rate to 1200 or 300 as appropriate;
 - d. Set the Charset to ASCII8;
 - e. You may or may not find the Inverted bit might be needed. ■

P5/4L4FN Ordered Off the Air

Bruce Paige, KK5DO, provided the following report, "I just received word from Ed, P5/4L4FN that the unfortunate and worst possible thing has just happened."

Friday evening, 2002 November 22, Ed was called into a meeting with the North Korean Government's "Radio Regulation Board" without any explanation, he was politely asked to quit all transmissions and pack all his radio equipment. Saturday, he spent all day on the roof disassembling his antennas and packing boxes. Government officials came by, sealed all the boxes, and when he left on December 10 for his two weeks R&R he was to take all Amateur Radio gear with him out of the country.

"This really hits the ham community hard", Bruce continued, "I for one was looking forward to a satellite contact on AO-40. I know that many of you were still awaiting your first QSO."

Ed will keep all the equipment for his next duty station. ■

[Telemetry continues on page 17]

Mozhayets RS-20 Telemetry Format

Name	Limits	Decoding	Description
RS 20			The callsign
UBS	N=100:170	U=N / 10 Volts	On board voltage
IBS	N=10:250	I=N / 100 Amperes	On board current
USUN	N=0:180	U=N / 10 Volts	Charge voltage from solar battery
ISUN	N=0:180	I=N / 100 Amperes	Charge current from solar battery
ITXA	N=0:170	I=N / 100 Amperes	D.C. current of the 435 MHz Tx
PTXA	N=0:70	P=N / 10 Watts	UHF power of the 435 MHz Tx
TTXA	N=50:190	T=N - 100 deg C	Temperature of the 435 MHz Tx
ITXB	N=0:150	I=N / 100 Amperes	D.C. current of the 145MHz Tx
PTXB	N=0:70	P=N / 10 Watts	VHF power of the 145MHz Tx
TTXB	N=50:190	T=N - 100 deg C	Temperature of the 145MHz Tx
TEXT	N=30:250	T=N - 100 deg C	Temperature of the outer case
TINT	N=30:190	T=N - 100 deg C	Temperature of the inner case
TOR	N=10:250	T=N - 100 deg C	Temperature of the Earth sensor
UOR	N=0:100	U=N / 10 Volts	Temperature of the Sun sensor
MTX	N=0:255	-	Table of operational modes. The housekeeping info.
MRX	N=0:255	-	Table of operational modes. The housekeeping info.
RS 20			The callsign

The Satellite Station You Already Have

by Lee McLamb KU4OS

In this article I am going to tackle the idea that "getting into satellites is too expensive." First let me agree that you CAN spend a lot on satellite gear. But that is true for any aspect of our hobby. But, if you are like me, very often experimenting with a new mode means trying to figure out what you can do with what you already have. So let's take a look at rigs you may already have and which satellites you can already use.

As you can see in the table below, the grey shaded areas show that a simple 2M FM rig will get you started with two satellites.

If you have a multi-mode dual band radio you are equipped for 12 satellites and adding a 10M receiver lets you access both operating modes of AO-7. The only one missing from the list is AO-40.

There is only one additional item needed to get on AO-40. You'll need an S-Band (2401 MHz) down converter installed ahead of the 2m/70cm CW/SSB rig. The converter receives the 2.4 GHz from AO-40 and converts it to 2m. Then you can use the 70cm part of the radio as the uplink

transmitter. Downconverters start at about \$60.

Now that you can see which of your rigs will let you work which satellites. I hope to be hearing you on the birds soon. If you have a question about getting started please feel free email me at ku4os@amsat.org. ■

	ARISS 145.99 Packet Up 145.20 FM Voice Up 144.49 FM Voice Up 145.80 Downlink	PCSat 145.825 Packet Up 145.825 Packet Down (Digipeat) Also 144.39 APRS	UO-14 145.975 FM Voice Up 435.070 FM Voice Down	AO-27 145.85 FM Voice Up 436.975 FM Voice Down	IO-26 145.875, 145.900, 145.925, 145.950 1200 baud packet	UO-22 145.900 Up 435.120 Down 9600 baud packet	TO-31 145.925 Up 436.925 Down 9600 baud packet	FO-20 145.90 to 146.00 CW/LSB Up 435.80 to 435.90 CW/USB down	FO-29 145.90 to 146.00 CW/LSB Up 435.80 to 435.90 CW/USB down	AO-7 (B) 432.125 to 432.175 CW/LSB Up 145.975 to 145.925 CW/USB Down	AO-7 (A) 145.85 to 145.95 CW/USB Up 29.400 to 29.500 CW/USB Down
2M FM Rig											
Dual Band 2M/44 FM Rig											
2M CW/SSB 435 CW/SSB											
2M CW/SSB 10M CW/SSB											



Dale Hershberger, KL7XJ, in Soldotna, Alaska, uses a **SatEL Az-EL!** to mount a 3' N3IYR circular polarization offset dish for his AO-40, 2.4 GHz downlink, and a M2 70 cm 11 element Yagi for his uplink. Dale is about to install a DEM RHCP helix for a 1.2 GHz uplink.

AZ-EL on a Budget! SatEL's Az-EL! with Control Processor and two Windows® drivers, seen at Dayton last May. "We do dishes!" (3 ft.)

Track AO-40, the space station, and LEO sats at a fraction of the cost. Uses sat pass data exported by either **InstantTrack®** or **Nova for Windows®**.

NEW! Model 5 Az-EL!, steps in 5-degree steps, supporting 3', 8 deg, 24 dBi dish antennas, AND... also allows tracking thru North without retracing 360 deg!

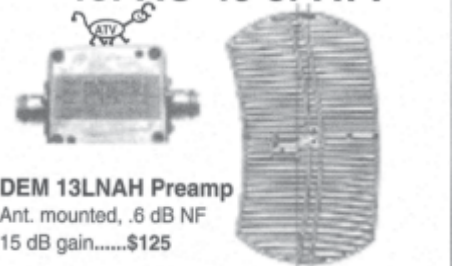
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Why AO-40 Needs A Regular Attitude Adjustment

By Howard Long, G6LVB (g6lvb@amsat.org)

Operators of AO-40 may be wondering why there are periods when the satellite has to be manoeuvred from ALON/ALAT = 0/0, which means that for periods of several weeks it's often difficult to make QSO's, or hear and decode the beacon. The purpose of this article is to explain the reason behind this off-pointing.

The reader will need to be conversant with common AO-40 operating terms such as squint angle and ALON/ALAT. These terms are described in the excellent AO-40 mini-glossary at <http://www.amsat-dl.org/journal/adlj40ge.htm>.

ALON/ALAT) or maintain attitude and therefore control the spacecraft.

- (b) Beyond about $\pm 45^\circ$ it's not possible to support all the usual onboard systems such as the transponder and the RUDAK without entering negative power budget territory. When the sun angle is between $\pm 45^\circ$, the spacecraft can be kept in a positive power budget, and the sun sensor can maintain and report attitude, so the high-gain antennas can point directly towards the Earth at apogee (ie, ALON=0 and ALAT=0).

would be beyond 45° if the ALON/ALAT remained at 0/0. Figure 1 shows the long term repetition of these periods if ALON/ALAT was maintained at 0/0.

So now that these 'bad' sun angles exist, where does the off-pointing (adjusting ALON/ALAT from 0/0) help? To explain this, some diagrams will be needed. Firstly, it's important to know how the sun angle is measured.

Referring to figure 2c, if the sun angle is zero, then the sun's rays fall directly onto

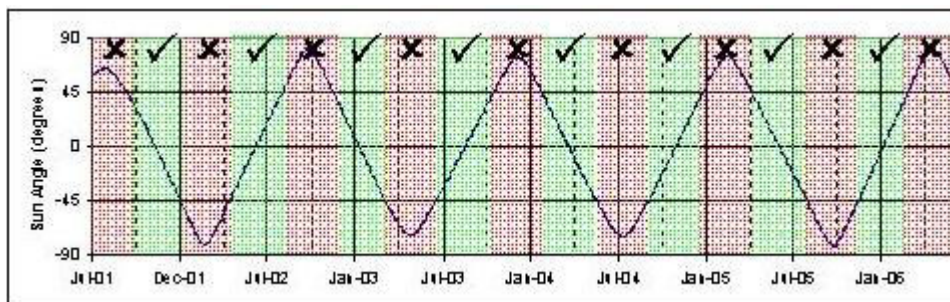


Figure 1: Sun angles on AO-40 if ALON/ALAT is held at 0/0. Good sun angles from O-40's perspective are between $\pm 45^\circ$. Beyond this the spacecraft will suffer a significantly reduced power budget and the spin-stabilised sun sensor will not provide data for attitude determination

So Why the Manoeuvrings?

Normally, for tracking purposes, only the orientation of the spacecraft relative to the observation point on Earth is considered. For the purposes of explaining the ALON/ALAT attitude manoeuvres it's necessary to change our conventional view and consider the position of the spacecraft relative to the Sun. This is because the attitude changes are required because of the orientation of the spacecraft relative to the Sun.

There are two reasons why these attitude manoeuvres are required:

- (a) There is a spin-mode sun sensor on the spacecraft measuring up to $\pm 45^\circ$. Beyond this, there is no easy way to measure the sun angle. Without being able to measure the sun angle, it is not easy to ascertain the attitude of the spacecraft (the

In order to maintain the sun angle on the spacecraft within the $\pm 45^\circ$ constraint, the attitude (ALON/ALAT) is altered by using the magnetorquers. This means that the high-gain antennas now point away from the earth at apogee (ALON/ALAT = 0/0), and this leads to significantly reduced (or occasionally no) useful transponder times. Every 216 days (within a week or so), the cycle between 'good' and 'bad' sun angles repeats. For about half of these days, the sun angle will be between $\pm 45^\circ$ and ALON/ALAT may be maintained at 0/0, with the sun sensor providing useful data. A 'bad' sun angle is one where the incident angle of the sun on the spacecraft's solar panels

the solar panels and there is maximum power. As the angle increases or decreases away from 0° , the power decreases from the solar panels, and beyond $\pm 45^\circ$, not only is it not possible to maintain sufficient power for all systems, but also the sun disappears from the sun sensor's view.

Shown in figures 3 and 4 (opposite page) are representations of how sun angles would affect AO-40 over a period of time if ALON/ALAT is kept at 0/0. Between about 29 July 2002 and 15 November 2002, the sun angle would be in excess of 45° .

(continued on page 13)

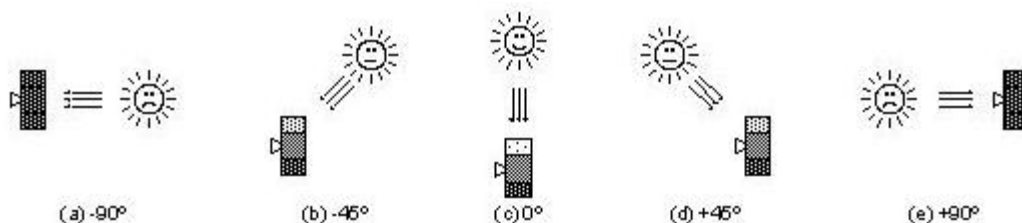


Figure 2: Sun angles on AO-40's solar panels

Also shown in figure 3 is the orbital precession of about 0.1632° per day, where the elliptical orbit itself slowly turns. If there were no orbital precession, the effect of sun angles would be synchronised with the Earth's orbit, and there would be precisely two periods of poor sun angles per year. The orbital precession is primarily due to the Earth's equatorial bulge. This is reflected in the Keplerian elements by a change in the RAAN parameter. The RAAN change moves ALON/ALAT coordinate system in space.

Figure 5 shows the attitude changes made to the spacecraft during the period 2 August 2002 to 17 November 2002 when sun angles were not optimum. It shows the changes made to the spacecraft's attitude during this period in order to maintain sufficient sun on the solar panels and sun sensor.

Hypothetically, moving to three-axis stabilisation would still require off-pointing. However, because of the relatively rapid effects of three-axis stabilisation compared to magnetorquing, it might be possible to temporarily move the spacecraft to a more favourable position for an hour or two each orbit assuming that the batteries had sufficient charge to support this.

Had AO-40 assumed its designed inclination, under a spin stabilised scenario, these 'bad' sun angles would still occur, but would be far less apparent (OSCAR-13, for example, still had to be off-pointed on occasion).

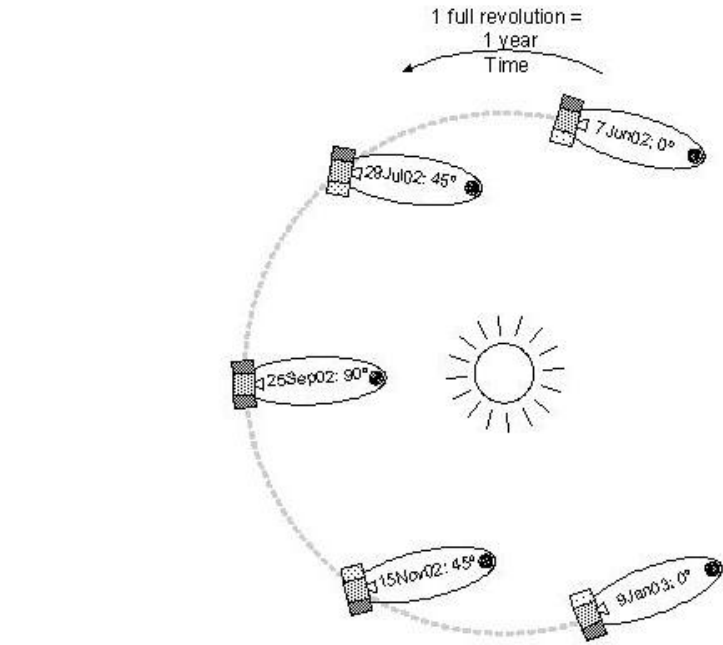


Figure 3: Sun angles on AO-40 if ALON/ALAT was to be kept at 0/0, over part of the year. This also shows the slow precession of the orbit (0.1632° per day) where the ALON/ALAT co-ordinate system slowly turns.

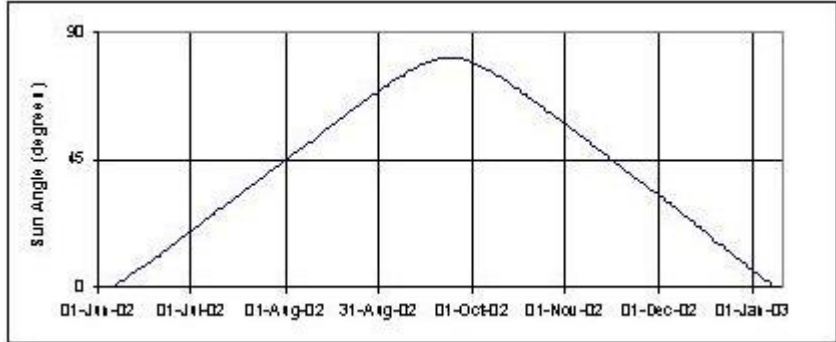


Figure 4: Graphical representation of sun angles for the period under examination if ALON/ALAT was to be kept at 0/0

In Conclusion

AO-40 will continue to require to have ALON/ALAT adjusted away from 0/0 on a repeating cycle which lasts every 216 days or so. This is because of angle of the sun on the spacecraft. For about half of this 216 day cycle, ALON/ALAT can be kept at around 0/0. For the remaining time the attitude will be adjusted in order to (a) keep sufficient sun on the solar panels and (b) allow the sun sensor to maintain attitude and provide attitude data to keep the spacecraft under control.

During the more extreme periods of off-pointing, there are periods of a few weeks of large squint angles for Earth observers, making it difficult if not impossible to make QSO's.

Acknowledgements:

Stacey Mills W4SM, Jerry Brown K5OE ■

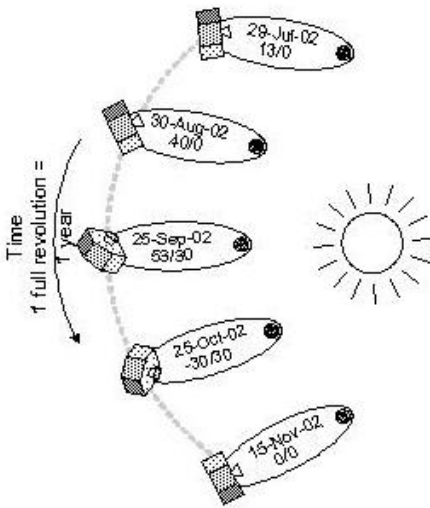


Figure 5: ALON/ALAT changes to keep sun angle under 45°

Date	ALON	ALAT
29-Jul-2002	13	0
5-Aug-2002	20	0
9-Aug-2002	25	0
18-Aug-2002	30	0
30-Aug-2002	40	0
2-Sep-2002	45	2
11-Sep-2002	45	7
15-Sep-2002	48	10
23-Sep-2002	48	15
25-Sep-2002	53	30
7-Oct-2002	20	30
14-Oct-2002	0	30 (Projected)
25-Oct-2002	-30	30 (Projected)
8-Nov-2002	-15	15 (Projected)
15-Nov-2002	0	0 (Projected)

AMSAT OSCAR-E Project Status Update

A New LEO Satellite From AMSAT-NA

By Richard M. Hambly, W2GPS

This status report about AMSAT-OSCAR-E (“Echo”) is an update to the presentation given at the Dayton Hamvention and the articles published in the *AMSAT Journal* (May/June 2002) and CQ/VHF Summer 2002.

BACKGROUND

Following the 2001 Annual AMSAT-NA Meeting in Decatur GA, the Board of Directors met and asked Dick Daniels (W4PUJ), Tom Clark (W3IWI) and Rick Hambly (W2GPS) to review a proposal for “a new small satellite project.” The team’s report was presented to the Board during a teleconference on 17Jan02 and the Board unanimously approved the project.

AMSAT-NA built and launched the original Microsats in 1990. These were AO16, DO17, WO18, and LO19. The descendents of the Microsat legacy include IO26, AO27, MO30, and SO41. Each of these descendents has improved on the original design. The project team recommended that AMSATNA take full advantage of these improvements so, on 8Feb02, AMSAT-NA entered into an agreement with SpaceQuest, Ltd. of Fairfax, VA whereby SpaceQuest will provide AMSAT with the basic components of AOE and leave it to AMSAT members to add any specialized payloads that may be desired. SpaceQuest is led by AMSAT members Dr. Dino Lorenzini (KC4YMG) and Mark Kanawati (N4TPY).

On 20Apr02 the AMSAT Board met at SpaceQuest to see firsthand that everything was going as planned. After the tour of SpaceQuest, the Board reconvened across the street in ARRL’s DC area offices where there were presentations and an extensive review of the project. It was at this meeting that the Board agreed to postpone the launch until late 2003 to provide adequate time for the development of optional payloads.

The first public presentation on AO-E was at the annual spring AMSAT-DC symposium at NASA Goddard Space Flight Center on 5 May 02. The presentation was significantly compressed for the Dayton Hamvention AMSAT Forum on 18 May 02.

Full details of the project were published in the May/June *AMSAT Journal*. A reprint of

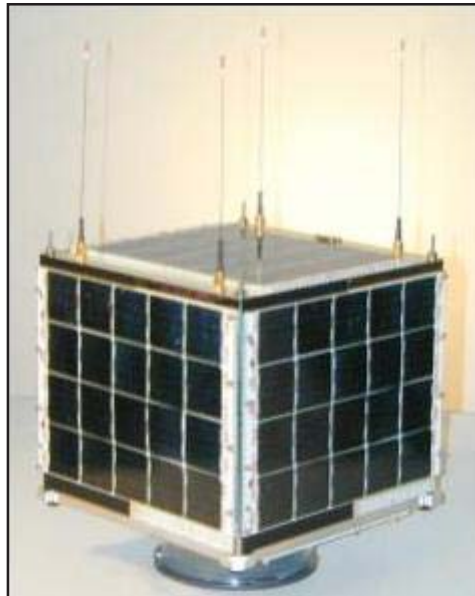


Figure 1: Mechanical Model of AO-E Class Microsat

the Journal article has appeared in the Summer 2002 issue of CQ/VHF magazine. Throughout the year the AMSAT project team (W4PUJ, W3IWI, and W2GPS) has met on a regular basis with SpaceQuest and others to review the progress of AO-E and to discuss the various optional payloads that are under consideration.

FEATURES

The AMSAT OSCAR-E satellite will offer users a strong set of features even before optional payloads are added. These include:

- Analog operation including FM voice.
- Digital operation including APRS.
- High downlink power.
- Multiple channels using two transmitters.
- Simultaneous voice and data.
- Multi-band, multi-mode receiver.
- Geographically based personalities.
- True circular UHF antenna that maintains its circularity over a wide range of squint angles.

TECHNICAL DESCRIPTION

AMSAT OSCAR-E will be a step forward in the evolution of Microsat technology, with better receivers, higher power transmitters, and new operating modes.

The infrastructure of the satellite has many improvements over earlier generation Microsats, including:

- Faster and more capable IHU processor.
- Higher data rates on downlinks.
- Autonomous, self-healing, high efficiency power management system.
- Upgraded, highly capable, software package.

Figure 2: The AMSAT Board, Project Committee and SpaceQuest personnel at SpaceQuest 20Apr02



- Store and forward with continuous monitoring and geographically defined data forwarding.

The internal subsystems have been described in detail in the AMSAT Journal article (May/June 2002) so only a summary is presented here.

The core elements of the AMSAT OSCAR-E satellite are being provided by SpaceQuest. This provides the basic platform on which AMSAT can build using optional payload trays and external modifications.

The subsystems that make up the core elements of AMSAT OSCAR-E are:

- The physical structure
- Attitude control
- Central processor hardware
- Spacecraft flight software
- Power generation and distribution
- Command and control
- A basic set of receivers, and transmitters
- Antennas.
- Space for optional payloads

Physical Structure

AMSAT OSCAR-E is made up of a stack of five machined aluminum modules each measuring 23.5mm x 23.5mm. The height of the stack is 24.5mm.

One module is empty and is to be used by an AMSAT supplied payload. Internal to the module there is 200mm x 220mm of space with rounded corners. The height is about 50mm.

Figure 4 shows a photo of a typical Microsat structure.

Active Magnetic Attitude Control

The active magnetic attitude control has replaced the passive system as one of the core satellite subsystems. This will allow the spacecraft to be oriented to favor communications in the Northern or Southern Hemispheres at different times.

This attitude control system replaces the permanent rod magnets with semi-permanent electromagnets. Electronic circuits are required to polarize and condition the magnetic rods.

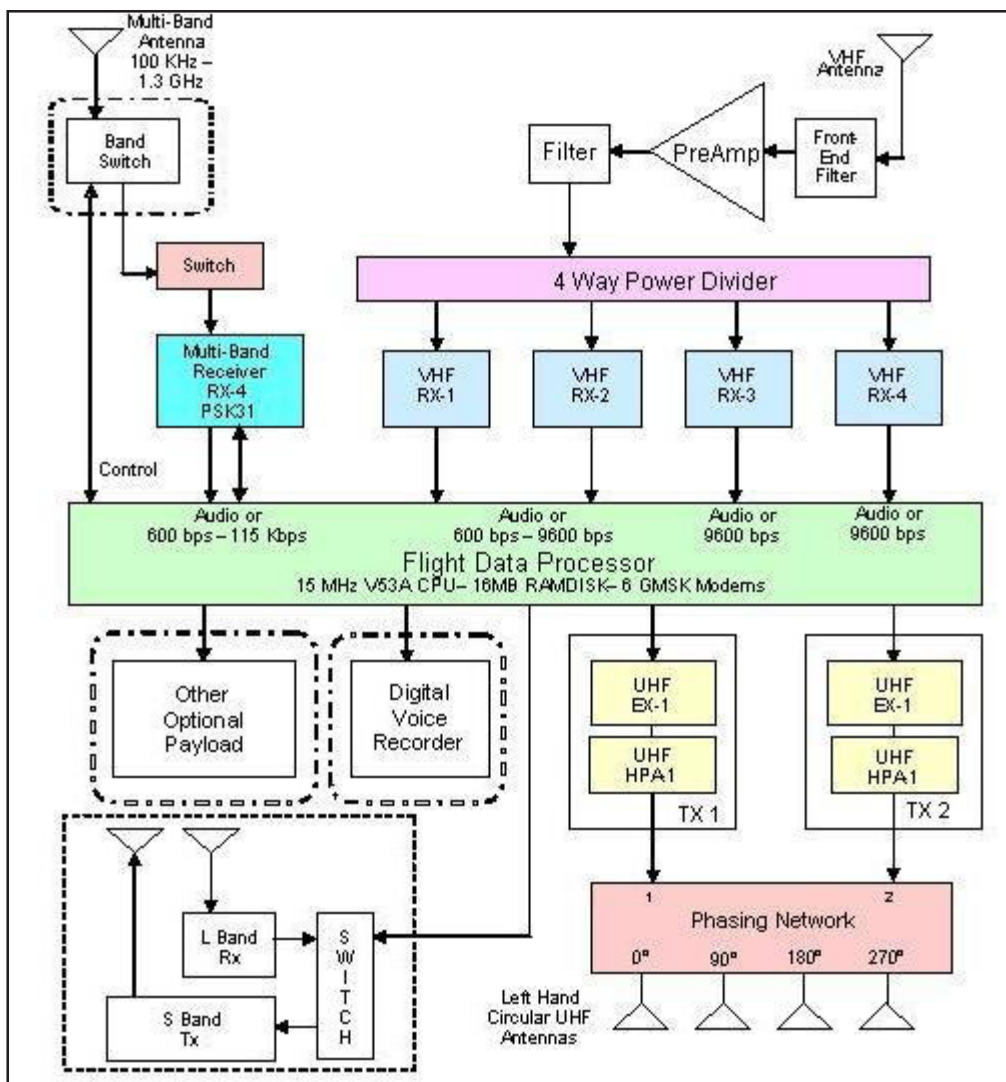


Figure 3: Conceptual Block Diagram of the AMSAT OSCAR-E Spacecraft

The Earth-pointing direction is on the order of ± 20 degrees in the temperate zones, varying with orbital inclination.

As this is being written Lou McFadin W5DID has the stabilization rods for winding. Doug Sinclair is designing and building the electronics to control magnetization of the rods.

Central Processor Hardware

AMSAT OSCAR-E includes an improved Integrated Flight Computer (IFC) recently developed by Lyle Johnson WA7GXD.

The improved IFC used a new six layer circuit board and includes a flight-proven, low-power NEC V53A processor Central Processor Unit (CPU) that runs at 30MHz, 3x faster than the previous design. In addition to its 1Mb of error-detecting and correcting (EDAC) memory, it has 16Mb of

RAM and 16Mb of Flash memory for mass storage.

The IFC board includes two GMSK modulators that can operate up to 115K Baud, and six GMSK demodulators that can operate up to 14.4K baud. Also included is a PL tone decoder.

The Spacecraft Operating System (SCOS), also flight proven on numerous spacecraft.

Hardware and software development are facilitated through the use of the SpaceQuest "FlatSat" model, see Figure 5.

Spacecraft Flight Software

The boot loader provides the minimal set of functions required to verify the satellite health and load the operating system. The bootloader is being tweaked to improve the uplink.

The Spacecraft Operating System (SCOS) has been used on all of the Amateur Radio Microsat projects to date. Harold Price has agreed to allow AMSAT to use SCOS in AOE without charge.

The Mission Software provides complete control over all aspects of the satellite, including experiments and attitude control. This software can be loaded into FLASH from the ground after launch.

Power Generation and Distribution

The AMSAT OSCAR-E Power Subsystem consists of a Battery Control Regulator (BCR), GaAs solar panels, matched flight cells, voltage regulators and a power activation switch.

The Battery Control Regulator (BCR) converts solar panel power to system power, and manages battery charge and protection. It is a switching design with a measured efficiency of 89 percent.

Six GaAs Solar Panels, which are mounted on all six sides of AMSAT OSCAR-E, produce a bus voltage of approximately 16 volts. The cells that have been purchased for AO-E are among the best available, with conversion efficiency of over 25%. Mark Kanawati will personally do the layout of the cells onto the panel. He proposes to fly without a glass cover on the cells, which requires more careful handling but gives an additional 1.5% in output.

The battery configuration is a matched set of six NiCd cells at 4.4 Ah each with a nominal battery voltage of 8 V dc.

The BCR provides multiple switched 8-V lines for both transmitters and other high power applications. There are also 3.3-V and 4.6-V switching regulators, capable of over 250 mA output each, with multiple switched and unswitched outputs.

Command and Control – Ground Station

The Bootloader application communicates with the satellite's bootloader upload code changes or to load and execute operating system tasks.

The Housekeeping program communicates with each of the tasks onboard the satellite.

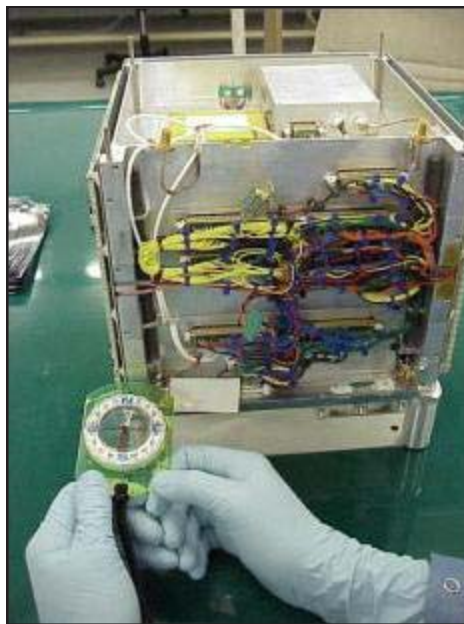


Figure 4: Typical Microsat Structure

The Telemetry Gathering and Reporting program downloads and displays satellite health information.

Each of these programs need to be written or re-written by AMSAT volunteers! This task has not yet been assigned.

Receivers and Transmitters

Four miniature VHF FM SpaceQuest receivers are used for both command & control and for user links. Each receiver consumes less than 40 mW and weighs less than 50 gm.

Two SpaceQuest UHF FM transmitters provide the downlinks and can be operated simultaneously. Nominal power output is 7 watts. The transmitter modules are being redesigned to reduce their overall height and to move the connectors to one end.

Antennas

The VHF antenna consists of a very thin quarter-wave (18-inch) vertical whip mounted in the center of the top surface of the spacecraft.

AO-E has a UHF Turnstile Antenna that is fed by a strip line hybrid antenna phasing network that provides the appropriate quadrature phase and amplitude to each of four output antenna ports to produce true circular polarization over a wide range of squint angles. As currently designed, the turnstile provides left hand circular polarization. SpaceQuest is looking into redesigning the turnstile for right hand circular polarization but this may not be feasible.

Three additional antennas are provided in a cluster in the center of the bottom face of the satellite. One is an 18" whip with dual feed electronics to feed the LF/HF/VHF/UHF wideband receiver. This antenna is still under development. The other two are ¼ wave whips for L and S bands to support a proposed Mode L/s transponder.

Link Budget Data

The following data is approximate and is provided for those wishing to make preliminary link budget calculations.

Transmitter: 70cm band, fixed frequency crystal controlled. Power output is 12 Watts maximum and is adjustable over a range of 1 to 12 Watts. The best efficiency is achieved at 7 Watts output. There are two transmitters that can be operated simultaneously.

Hybrid Coupler: The two transmitters are combined to feed one antenna. Loss in the hybrid coupler is about 0.5 db or less.

UHF Antenna: 1 to 2 dBic gain (2dBic at ± 40 degree squint). See Figure 6.

Note that with these numbers it is possible to exceed the FCC recommended power flux density of $-125 \text{ dBW/m}^2/4\text{kHz}$.

When transmitting data the waveform is GMSK ("softened" FSK, not phase coherent like true GMSK). The data rate can be set to



Figure 5: Mark N4TPY with "FlatSat"

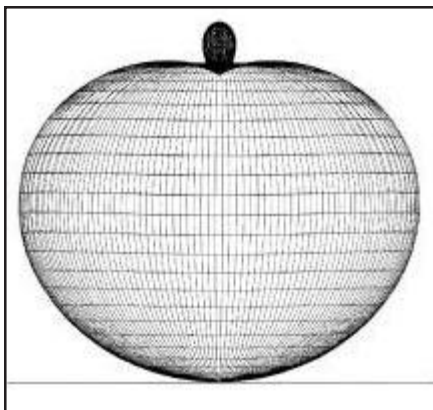


Figure 6: Turnstyle Antenna Radiation Pattern

anything up to about 56K baud, limited primarily by the FCC channel bandwidth limit (100KHz). Normal operation will probably be at 9600 baud to be compatible with all the radios and modem that are commonly available.

Receive Antenna: A 1/4 wave whip in the center on the face that normally looks up when over the Northern Hemisphere. It has about 1.5dBi (linear) gain.

Receive Cable and Filter assembly: 1dB loss. LNA: 0.7dB Noise Figure. 18dB gain.

Receiver: 15KHz Bandwidth in voice or data (supports up to 9600 baud data).

OPTIONAL PAYLOADS

The optional payloads under consideration for the AMSAT OSCAR-E mission have been described previously so only status information is provided here.

Advanced Data Communications for the Amateur Radio Service (ADCARS)

A number of meetings and discussions have been held with KA9Q, W2GPS, SpaceQuest and others. This is a difficult and generally poorly understood project. Much more work will need to be done if AO-E is to provide meaningful support for the development of this new technology.

L-Band/S-Band Communications System

This project may be combined with ADCARS. A project leader with experience in wide band transmitter and receiver design is needed.

GPS Receiver

AMSAT is still looking for a suitable candidate for this. Power consumption, size and weight of available equipment are the limiting factors here.

Active Magnetic Attitude Control

This project has been embraced by SpaceQuest and is now a part of the core spacecraft design.

Audio Recorder Experiment

This experiment, proposed by KK7P, will provide the capability for recording and playing back any audio channel. The CPU is also needed to support ADCARS. There is no progress to report on this project at this time.

Low Frequency Receiver

To become feasible, a way must be found to share the single 18" wideband receive whip between low frequencies, using a new E-field antenna interface amplifier, and VHF/UHF frequencies, which use a more conventional interface.

APRS

APRS can be supported in various ways through software only solutions. While it would be best to develop the software while the satellite is still on the ground, it is not essential. A volunteer is needed to do the software development.

PSK-31

PSK-31 will be supported by operational control. No additional development is necessary.

Multi-band Receiver/Antenna

This receiver is now a part of the core satellite system. The capability is limited only by the antenna design, which must be finalized.

High Efficiency Solar Arrays

This is now a part of the core satellite system. Cells have been obtained that have conversion efficiency in excess of 25% and will produce over 7 Watts per panel when facing the sun.

Robust Telemetry Link

Discussions continue with KA9Q regarding implementation issues. This is another very valuable project that is now well understood.

CONCLUSION

The core elements of AMSAT OSCAR-E are under construction now by SpaceQuest.

The AMSAT OSCAR-E project team is still working to finalize plans for optional payloads. This is proving to be especially difficult.

It is hoped that AMSAT OSCAR-E will be the first in a series of new low-cost LEO satellites, each to carry optional payloads of interest to the AMSAT community. ■

Telemetry

[continued from page 10]

UO-22 Available to Users Again

More details are provided by Chris, G7UPN/ZL2TPO, "UO-22 is operating OK at the moment. Some new software has been loaded to try and keep the downlink operating most of the time." Chris also noted that this veteran satellite is starting to show some signs of age. "It seems that after around 60000 charge/discharge cycles the NiCd batteries are starting to show their age (!)", Chris commented. He added "It's probable that the power system will no longer be able to support operations when UO-22 enters a period of eclipse in a few months time although we'll do all we can to try and keep it operational."

Chris also provided some insight into the plans for managing the power budget on UO-22. "The downlink will also be switched off from time to time over certain parts of the globe. Generally these quiet periods should be out of range of most stations. Currently, they are in the middle of the Pacific, Indian Ocean, and central China." Chris explains, "This is required to allow the attitude control system to operate correctly since the power system can not supply enough power to support both the transmitter and the magnetorquers."

Chris's closing suggestion is, "Enjoy the bird while you can! At 11 1/2 years it's doing well, but it may not be available for a lot longer." ■

[continues on page 25]

Proposal for a FEC-Coded AO-40 Telemetry Link

By Phil Karn, KA9Q (karn@ka9q.net)

Abstract

This paper proposes a new transmission format for AO-40 telemetry that uses strong forward error correction (FEC) coding. During fading, this format performs dramatically better than the current uncoded format. Weak-signal performance without fading is also significantly improved. The proposed format can be implemented entirely in software and uploaded to the AO-40 IHU.

The coding methods presented here are not new. They are drawn from deep space telecommunication standards and from direct satellite broadcasting. These methods, and the open-source software modules I have written to implement them, are broadly applicable to other amateur satellite links. The time has come to make FEC a standard feature of every amateur digital satellite link.

Introduction

AO-40 uses the same 400bps BPSK Phase 3 telemetry format designed in the mid 1970s and first flown on Phase 3A in 1980. It was also used on AO-10 (1983) and AO-13 (1988).

This format was a significant improvement over the simple digital communication methods then in use by radio amateurs, such as CW and RTTY. But its only use of error control coding (ECC) is a simple cyclic redundancy check (CRC) that can only detect errors, not correct them.

The Phase 3 format did not use any of the powerful error correction codes that had just been introduced on deep space probes such as Pioneer and Voyager. Although these codes are easy to encode even on a IHU, they were just too complex to decode on the personal computers then available to hams. Dedicated hardware decoders weren't practical either.

The situation has completely changed. Today's personal computer is an extraordinarily powerful digital signal processing (DSP) and encoding/decoding engine. The Pentium/Athlon (PC) and Power PC G4 (Macintosh) CPUs even provide "vector" instructions specifically intended for high performance digital signal processing. Similar instructions were once found only in high-end supercomputers like Crays. Indeed, the average PC now significantly outperforms Cray's early models.

With these advances, it is now fully practical to realize the benefits of FEC on AO-40 and future spacecraft. The primary benefit would be a dramatic improvement in the reliability of AO-40 telemetry when the antennas are off-pointed from earth and spin-induced fading is significant. Even under non-fading conditions, FEC coding would permit the acquisition of AO-40 telemetry with substantially smaller antennas than the uncoded format presently requires. The FEC format would also provide a substantial margin of safety during the commanding of spacecraft maneuvers.

Why Do We Need Coding?

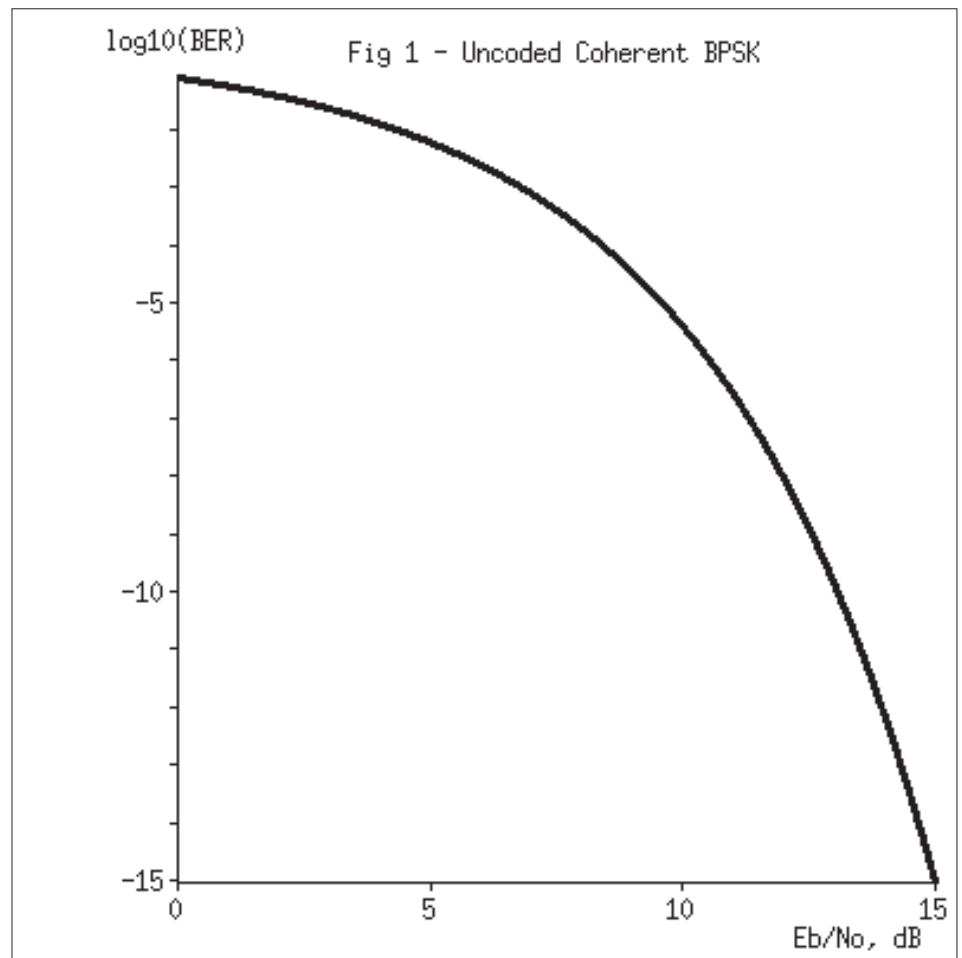
DC power on a spacecraft is phenomenally expensive to generate, so it must be used efficiently. Downlink transmitters are usually the biggest loads, so great lengths have been taken to maximize power amplifier efficiency.

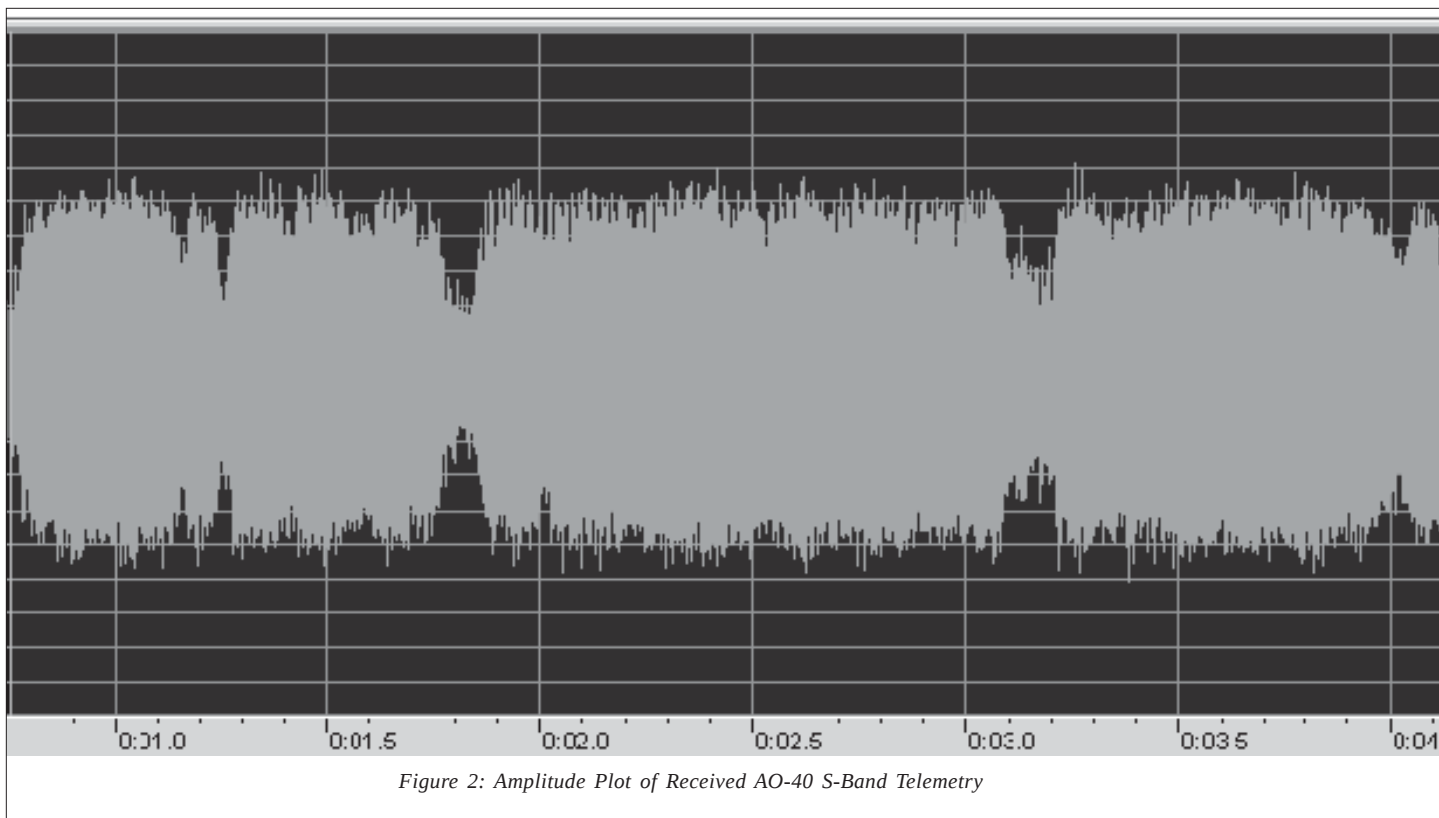
(AMSAT has been a pioneer in this area with its development of HELAPS and similar technologies). A high altitude spacecraft like AO-40 carries high gain antennas to avoid spraying RF power uselessly into space. These in turn require accurate attitude determination and control.

Ground station antennas are often limited in size by practicality and local regulation. Amateurs use the quietest preamplifiers available, despite their high cost, but there are still natural noise sources that cannot be eliminated.

Amateurs have spent a lot of money and effort to maximize the amount of RF power their satellites beam to earth, and to maximize the signal-to-noise ratios of these signals as received at their stations. But two critical elements of the system remain unchanged: modulation and coding.

Binary phase shift keying (BPSK), as used





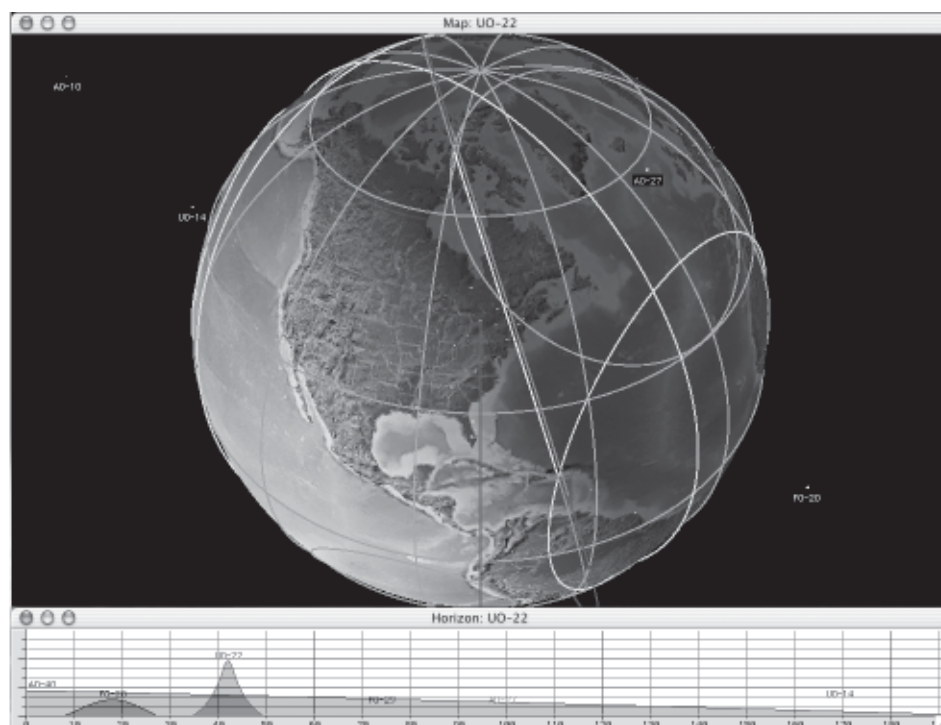
by the AO-40 telemetry beacon, is one of the oldest and most widely used modulation schemes in space communications. Figure 1 shows the bit error rate of an ideal BPSK demodulator as a function of the "per-bit" signal-to-noise ratio.

The "per bit SNR" is more commonly known as E_b/N_0 , the ratio of the received energy per data bit, E_b , to the noise spectral density, N_0 . I will use that term in the rest of this paper.

This plot makes several important assumptions. First, the demodulator is "coherent"; it recovers the phase of the transmitted carrier from the incoming signal, and it does so perfectly. Second, the only channel impairment is "white" Gaussian noise, such as the thermal noise of a preamp. There is no fading. This is an important point we'll return to later.

According to the Nyquist Theorem, BPSK must occupy a bandwidth of at least 1 Hz for every bit per second of signaling rate. i.e., its "spectral efficiency" is 1 bit/sec/Hz. And according to the Shannon Channel Capacity Theorem, there exists a signalling scheme with a spectral efficiency of 1 bit/sec/Hz that can achieve error-free performance provided that the E_b/N_0 is at least 0 dB. (No such scheme exists that requires an E_b/N_0 of less than 0 dB.)

As you can see, achieving a good error



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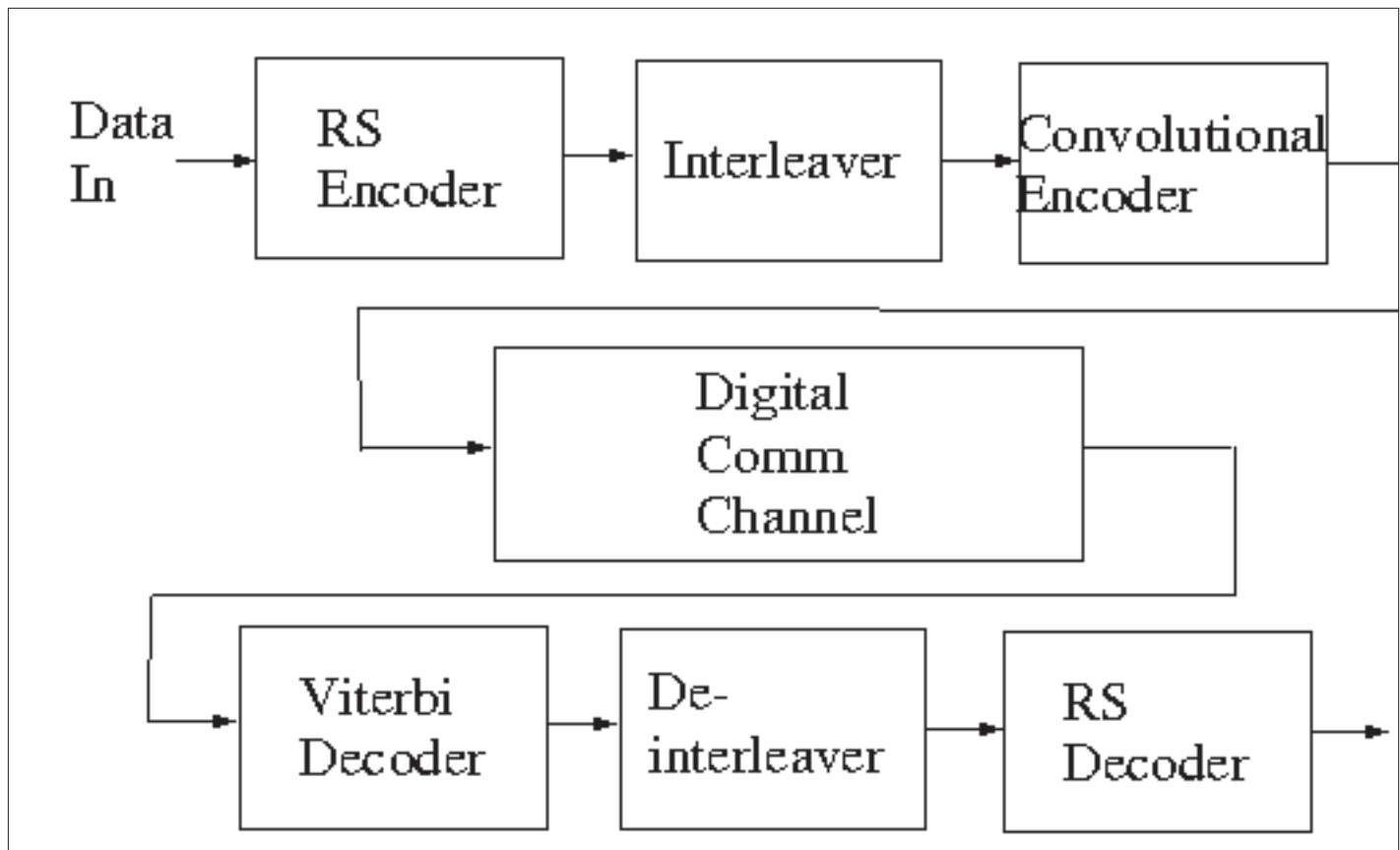


Figure 3: Concatenated Coding System

rate with uncoded coherent BPSK, even with a perfect demodulator, needs about 10 dB more power than the Shannon limit requires. How can we make up at least some of the difference? With forward error correction coding. The power we can save with a given FEC scheme over uncoded BPSK is the coding gain.

Coding On Fading Channels

On a fading channel, the case for coding is even more dramatic. The Rayleigh fading model is commonly used, as it accurately models propagation over multiple, time-varying reflected paths. EME and HF skywave are well modeled by Rayleigh fading. The Ricean model generalizes the Rayleigh model by adding a direct free-space path to the indirect multipath components. Land mobile channels are often modeled as Ricean.

Except for satellites on HF, most amateur satellite link fading is caused entirely by satellite spin or tumbling combined with non-uniform antenna patterns. This is the case when AO-40's antenna is off-pointed from earth. The fading envelope repeats predictably on every rotation, and depending on spacecraft attitude, the envelope can include one or more deep nulls. Figure 2 shows an amplitude plot of AO-40 S-band telemetry as received by W2GPS and WB4APR using the

12-meter dish at the US Naval Academy on January 18, 2001. The time span is 3.38 seconds, the spin period at that time. The receiver AGC could not be turned off, so the fading was even more severe than shown here.

Without FEC, a telemetry frame is no stronger than its weakest bit. A short, deep fade that causes a single bit error is enough to destroy an entire frame even if the average E_b/N_0 is high. Because a frame is about 11 seconds long and there can be multiple deep fades per satellite rotation when the antennas are not earth-pointing, every frame is almost guaranteed to have at least one bit error.

With FEC, however, the bits corrupted in a fade can be regenerated from the others that are received. It doesn't matter how deep the fades are, as long as most of the frame gets through.

So the coding gain that FEC can achieve on a fading channel depends on the fade depth. FEC that can "ride through" say, a 30 dB fade, can provide a coding gain of 30 dB over and above that provided on a non-fading channel. We amateurs can no longer afford to ignore such dramatic gains!

The Concatenated Reed-Solomon/Convolutional Code

A complete review of all FEC codes would fill a large textbook, so I'll limit my discussion to the code I'm proposing for use on AO-40. This is the concatenated Reed-Solomon/Convolutional code first flown on Voyager 1 and 2 in 1977, and now widely used in very similar form by every major digital broadcast satellite.

A "concatenated" code is formed by combining two separate codes, in this case a Reed-Solomon block code and a "short" convolutional code decoded with the Viterbi algorithm. (One sometimes hears the term "Viterbi code", but this is inaccurate. Viterbi's contribution was an efficient algorithm for decoding convolutional codes, which were already known at the time.)

Figure 3, above, shows a communications system that uses a concatenated code. The user data is first encoded with a Reed-Solomon code. The Reed-Solomon data is interleaved (reordered) and encoded again, this time with a convolutional code. At the receiver, the convolutional code is decoded with a Viterbi decoder, the data is de-interleaved and the Reed-Solomon code is decoded.

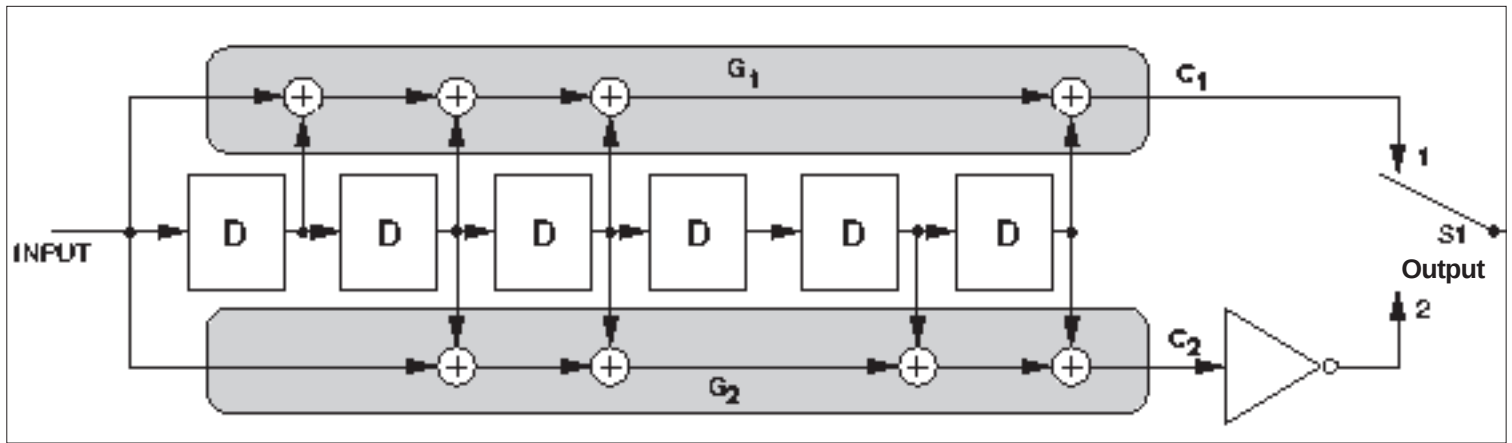


Figure 4: CCSDS Viterbi code, constraint length = 7, rate = 1/2

In this scheme the Reed-Solomon code is sometimes referred to as an "outer code", while the convolutional code is an "inner code". Why use two codes? And why the interleaver? To get the best of both kinds of codes.

Viterbi-decoded convolutional codes provide excellent coding gain on Gaussian channels with random channel bit errors, and they are readily adapted to soft decision decoding. If the demodulator can provide a "quality" indication with each incoming bit, the Viterbi algorithm yields an extra coding gain of about 2 dB over that from a demodulator with a simple slicer at its output. Typically 3- or 4-bit samples are used.

The Viterbi-decoded convolutional code first used on Voyager has become very widely used. It is a Consultative Committee for Space Data Systems (CCSDS) standard. The block diagram of the encoder is shown in Figure 4, above.

This particular code has a constraint length of 7 and a rate of 1/2. That is, there are taps at 7 points along the encoder shift register, and it generates two encoded channel symbols for each input data bit.

A description of the Viterbi algorithm is beyond the scope of this paper, but its performance on this code on a coherent BPSK channel with 3-bit soft decision symbols is shown in Figure 5.

Note the improvement over uncoded BPSK. To achieve a bit error rate of 10^{-5} , the coded channel requires an E_b/N_0 of about 4.5 dB. That's 5.1 dB less than uncoded BPSK. In other words, just by using this code you can cut your transmitter power by a factor of 3.2 and keep the same user data rate. Or you could increase your data rate by that same factor of 3.2 while keeping the same transmitter power, ground antenna, etc.

This does come at the cost of doubling the channel bandwidth, as the encoder gener-

ates two channel symbols for each data bit.

A Viterbi decoder still makes errors, and it cannot reliably tell you where they are. A telemetry system needs protection against these errors, so we need something else on top of the Viterbi-decoded convolutional coding.

One could just use a CRC, and some systems (e.g., IS-95 CDMA digital cellular) do just that. But if our data blocks are large enough, we can do better with a more powerful code.

Reed-Solomon (RS) codes are well known for their use in CDs and CD-ROMs. They are "block" codes like CRCs, only much more powerful. The RS code in my proposal is also a CCSDS standard, similar to Voyager's (255,223) RS code. Each code block contains 255 8-bit symbols. 223 symbols contain user data and 32 symbols contain parity computed according to the code specification.

A (255,223) RS code not only provides extremely reliable error detection, it can also correct up to $(255-223)/2 = 16$ symbol errors

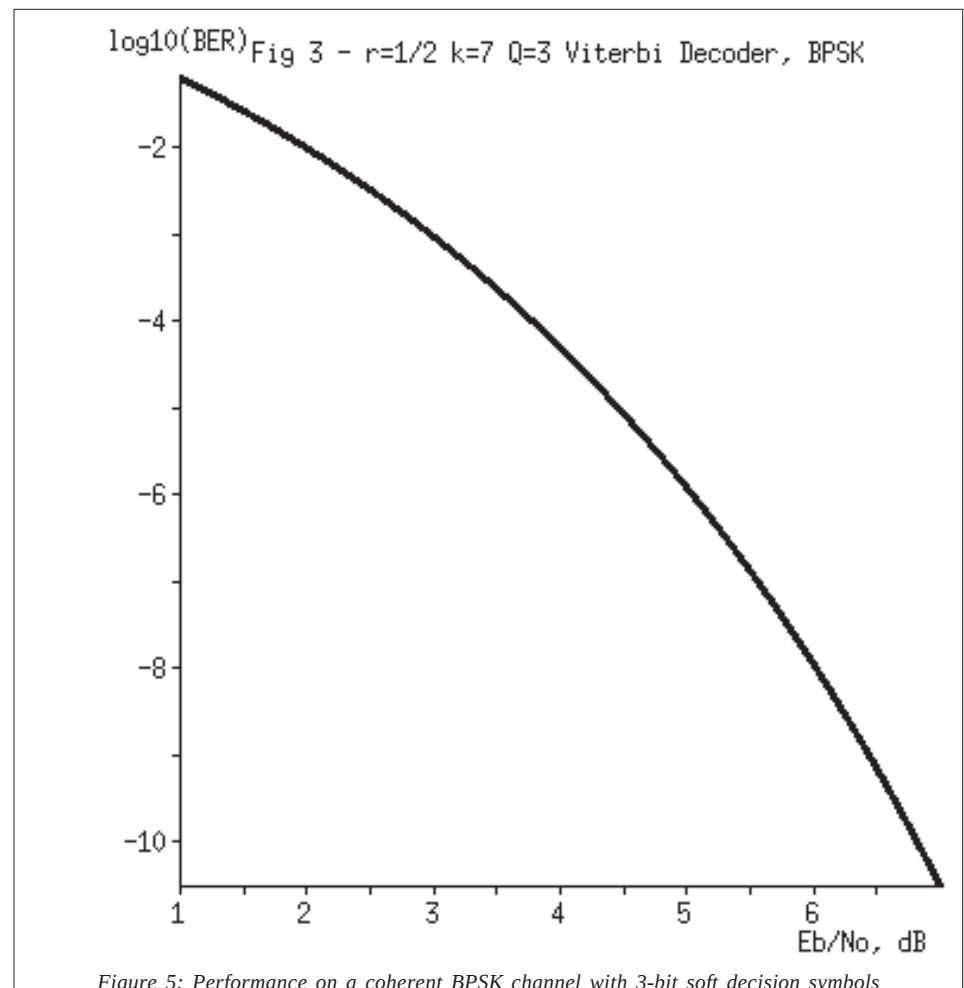


Figure 5: Performance on a coherent BPSK channel with 3-bit soft decision symbols

in each block. At least one bad bit in a symbol spoils the whole symbol; it doesn't matter if the other bits are also bad. This makes RS codes better suited to the correction of burst errors than random errors.

It turns out that Viterbi decoders always make their errors in bursts. This makes for an ideal marriage between a Reed-Solomon code and a Viterbi-decoded convolutional code. The Viterbi decoder does most of the work, and the RS decoder "mops up" most of the remaining errors. Any uncorrectable errors that remain are almost guaranteed to be detected.

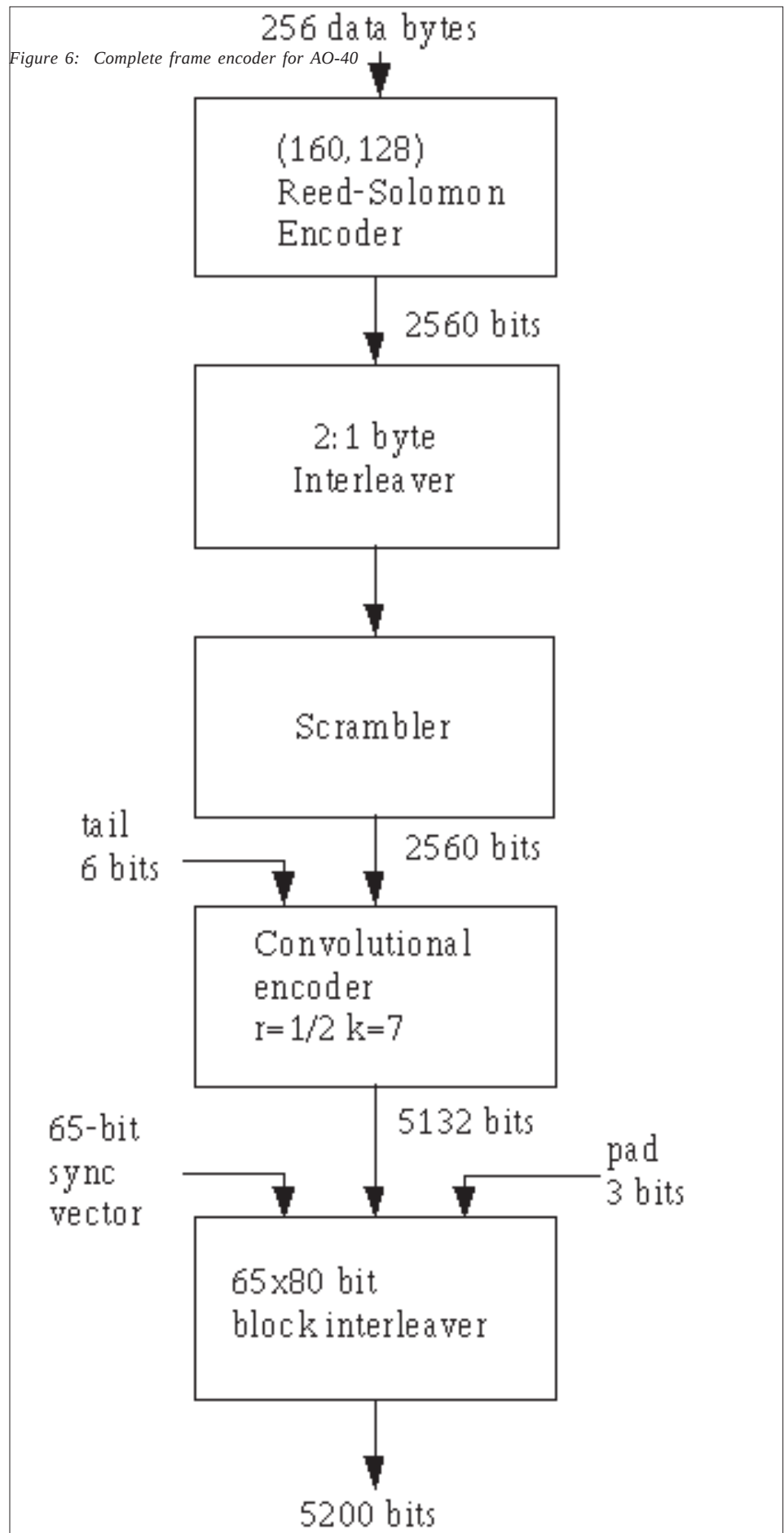
When these two codes are combined, the BER curve is a nearly vertical cliff at an E_b/N_0 of about 2.5-2.6 dB.

Applying the Concatenated Code to AO-40

Figure 6 is a block diagram of the complete frame encoder for AO-40. Besides the Reed-Solomon and convolutional encoders and the interleaver between them, several more components are included: a scrambler that ensures frequent symbol transitions regardless of the input data, and a second interleaver.

The current, uncoded Phase 3 telemetry frame has a data payload of 512 bytes. Early in the project, it was decided that a payload of only 256 bytes would be acceptable in the FEC format. This reduces the IHU RAM needed to build the encoded frame, and it keeps the frame from taking too long to transmit at the fixed rate of 400 bps.

The 256 bytes of telemetry data are divided into two blocks of 128 bytes each. Each block is zero-padded at the start with 95 bytes of binary zeros to make 223 bytes of data for the Reed-Solomon encoder. This zero-padding is reinserted at the decoder; it is not sent over the air. This shortening process effectively turns the original (255,223) code into a (160,128) code. Each block still has 32 parity symbols and can still correct up to 16 symbol errors. Because fewer symbols are actually transmitted over the air, the percentage of symbols that can be in error is increased, strengthening the code at the expense of greater overhead.



The 320 bytes of RS-encoded data are interleaved, scrambled and fed to the $k=7$ $r=1/2$ convolutional encoder. A "tail" of six 0-bits is added to the end of the scrambled frame to return the convolutional encoder to the all-zeros state.

Because fade-resistance is a specific goal, a second layer of interleaving -- unique to the AO-40 format -- was added after the convolutional encoder, just before the modulator. This is necessary because Viterbi decoders do not do well on fading channels. It was not needed on Voyager because that spacecraft is 3-axis stabilized and does not suffer from the kind of spin fading that affects AO-40.

For the same reason, the existing Phase 3 block sync vector scheme could not be used. A "distributed" sync vector, 65 bits long, is interleaved with the data so that a single fade at the wrong moment cannot kill the entire frame.

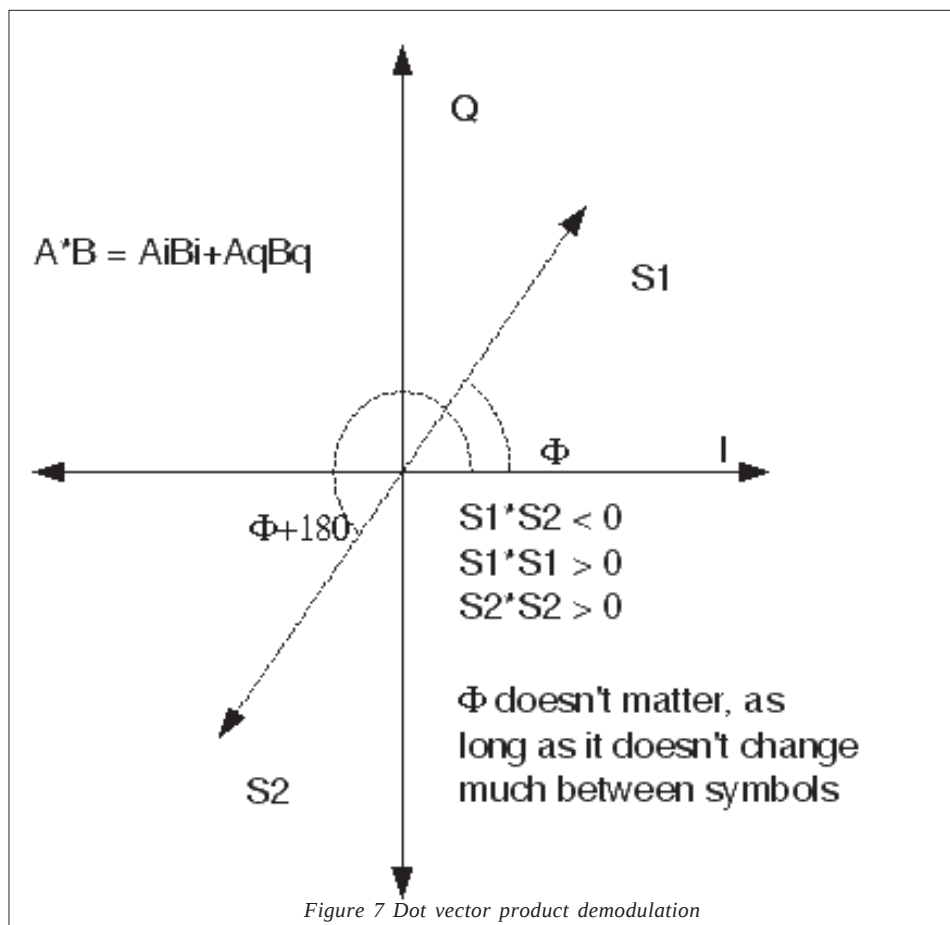
Each coded frame contains exactly 5200 encoded bits (binary channel symbols) and takes exactly 13 seconds to transmit at 400 bps. The user data payload is 256 bytes, or 2048 bits. The remaining $5200 - 2048 = 3152$ channel symbols contain FEC overhead, a sync vector, and a few spare bits.

A more detailed description of the format, and the rationale for each design decision, is in my paper, "Proposed Coded AO-40 Telemetry Format", published on my web page at <http://www.ka9q.net/papers/ao40t1m.html>.

Demodulators For Fading Channels

The coherent BPSK demodulators commonly used with Phase 3 telemetry often have trouble maintaining carrier lock on a fading signal. Not only are the amplitude variations a problem for the carrier tracking loop, but there can be a significant Doppler component due to antenna motion, especially at S-band. And there can be sudden phase jumps associated with specular reflections off spacecraft components. Strong FEC won't help us if the demodulator can't track the signal.

The answer is to use differentially coherent demodulation (DBPSK). A coherent detector extracts its carrier phase reference from a relatively wide sliding window of received symbols, but this window is a big target for a channel phase disturbance.



DBPSK only uses the phase of the symbol immediately before the one we're demodulating, so a short disturbance only affects a few symbols.

For DBPSK to work, we must specially encode the data at the transmitter. i.e., we want to encode a 1-bit not as a particular carrier phase, but as a change of phase from one symbol to the next. Similarly, a 0-bit is encoded as no phase change. That allows us to recover the data by directly comparing pairs of received symbols.

Fortunately, AO-40 already does this. The IHU includes a hardware differential encoder and a Manchester (biphase) encoder. If a 1-bit is to be sent, the 400 Hz beacon clock is inverted in phase from its previous setting; if a 0-bit is to be sent, the beacon clock phase is left unchanged. Bits thus encoded are then fed to the BPSK beacon modulator and to the transmitter.

DBPSK can be demodulated in software as follows. We take the digitized audio signal from the receiver and feed it to a complex (I&Q) mixer and low-pass filter.

The mixer "local oscillator" is set close to the incoming carrier frequency. This produces a complex baseband signal with a carrier frequency close to zero hertz. (This is commonly known as a "zero IF" conversion.)

Because the LO is not locked to the carrier, the zero-IF signal vector will slowly rotate in phase. The closer the LO is to the carrier frequency, the slower the vector rotation. At the same time, the vector will flip 180 degrees and return according to the modulation.

Refer to Figure 7, above. To extract the modulation, we compute the vector dot product of the complex baseband signal samples for the previous and current channel symbols. If there has been no change in phase between the two symbols, the dot product will be a positive number. If the phase has changed, the dot product will be negative. The magnitude of the dot product depends on the vector magnitude of both symbols; if the symbols are weak, the dot product will be small. We just flip the sign on each dot product, and we have our soft-decision values for our Viterbi decoder!

There's a little more to the problem. We have to know where each symbol starts and ends,

and we also need to know the approximate incoming carrier frequency so that the zero IF signal vector won't drift too much between each pair of symbols (not counting the modulation, of course).

Given the power of the modern PC, brute force works well here. I start by simply trying all possible combinations of carrier frequency and symbol timing, looking for maximum demodulator output. But I need not do this on every frame. Carrier frequency and subcarrier phase usually don't change much from one telemetry frame to the next, so I can simply use the values acquired for one frame as initial guesses for the next. If the guess is right, the frame decodes. If not, I can drop back and retry the frame with the brute-force search.

All this is still a lot easier to implement than coherent BPSK (CBPSK) demodulation with a Costas or squaring loop. And while DBPSK works well on channels with rapid carrier phase disturbances, CBPSK often fails completely.

But DBPSK has its price. On a non-fading channel, CBPSK outperforms DBPSK. A coherent detector produces a carrier phase reference from the energy of many channel symbols, while the DBPSK demodulator can use only the energy of one symbol as a reference.

At high E_s/N_0 ratios, such as those required for uncoded PSK, the advantage of CBPSK over DPSK is only a small fraction of a dB. (E_s/N_0 is the signal-to-noise ratio seen by the demodulator rather than the FEC decoder. In an uncoded system, a channel symbol and a data bit are the same thing, so $E_s/N_0 = E_b/N_0$. We've seen that this has to be about +10 dB for uncoded BPSK). This raises the question of why so many Phase 3 BPSK demodulators use coherent detection despite the increased complexity and difficulty in use.

But in a FEC-coded system, the E_s/N_0 is the E_b/N_0 times the code rate: about 0.4, or -4 dB in the present scheme). Thanks to the FEC coding gain, we can operate at a much lower E_b/N_0 of about 2.6 dB, and the E_s/N_0 is another 4 dB below that, or about -1.4 dB. That's low enough for the DBPSK penalty to become significant.

Test Results

I have tested my prototype demodulator on simulated channels with Gaussian (thermal) noise and with and without fading. Both NRZI and Manchester symbol filtering were tested, although only Manchester is compatible with the AO-40 IHU. (More on this

later).

NRZI encoding, Gaussian noise, no fading

Virtually 100% frame copy is achieved at $E_b/N_0 > 6$ dB. At $E_b/N_0 \leq 5$ dB, no frames are decoded at all. This sharp threshold is consistent with my use of the concatenated code, only it occurs 3.4 dB higher because I use DBPSK demodulation rather than coherent BPSK. However, I'm still 4 dB better than uncoded BPSK.

NRZI encoding, Gaussian noise, sinusoidal fading

In this test, the signal is first multiplied by a 3.3 Hz sinusoidal envelope to simulate spin modulation. The fading envelope goes through two nulls and two carrier phase reversals per cycle. Noise is then added to make a specified average E_b/N_0 , i.e., the signal peaks are higher than in the non-fading case.

In this case, 100% copy is achieved at $E_b/N_0 \geq 8$ dB, but only about 10% of the frames are decoded at $E_b/N_0 = 7$ dB. In this particular situation, the addition of fading results in about a 2 dB impairment.

Biphase encoding, gaussian noise, no fading

This test uses a transmit filter with an impulse response derived from analysis of the hardware filter in the AO-40 beacon transmitter. The demodulator uses an identical matched filter.

Solid copy is achieved at $E_b/N_0 \geq 7$ dB, and 50% copy at $E_b/N_0 = 6$ dB. This is about 1 dB worse than with NRZI. This is due to inter-symbol interference in the transmit filter that is unequalized in the receiver. A receive equalizer should remove most of this penalty, but some may remain.

Biphase encoding, gaussian noise, sinusoidal fading

Solid copy at $E_b/N_0 \geq 9$ dB, ~50% at 8 dB, and no copy below 8 dB. This is consistent with the 2 dB penalty seen in the fading NRZI case, and with the 1 dB penalty due to the unequalized biphase receive filter.

Discussion

These tests clearly demonstrate the benefits of FEC and DBPSK demodulation under non-fading and, especially, fading channel conditions. Although at least 4 dB of mar-

gin is provided on a non-fading channel, the really dramatic improvement is on the fading channel. Because the simulated fading envelope passes through zero amplitude (minus infinity dB), copying this signal without FEC would be totally futile even when the average E_b/N_0 is extremely high. Yet with the FEC format, fading signals that are barely audible to the ear at fade peaks can be reliably decoded.

The FEC format's fade tolerance depends on fades being brief relative to the 13 sec frame time. Tests do show worse performance on very long fade periods, as expected. This could be improved with a longer interleaver, but only at the expense of increasing the delay between the generation of a frame by the IHU and its decoding on the ground. So 13 seconds was chosen as an initial compromise. If experience shows that a longer interleaver would be desirable, the format can be changed.

On a fading channel, we have no choice but to use differentially coherent (DBPSK) demodulation. But I could improve the performance of my demodulator under non-fading conditions by adding a CBPSK demodulator. DBPSK could be tried first, and it will succeed if the signal is strong enough. If not, the CBPSK demodulator could then be tried automatically.

Another possible enhancement is suggested by the technique developed by Paul Willmott, VP9MU, to merge AO-40 telemetry fragments from multiple stations. This recovers data that might not be available from any one station. This approach is even more powerful when FEC coding is in use, and it is routinely performed on signals from the Galileo spacecraft orbiting Jupiter. An array of antennas and receivers is pointed at the spacecraft, and the separate signals are synchronized and combined before demodulation and decoding.

Prototype Software

My software prototype implementation of an encoder, channel simulator and demodulator/decoder is available on my web site, <http://www.ka9q.net>, under the terms of the GNU General Public License.

The prototype package uses a set of general-purpose DSP and FEC libraries that can easily be reused in other projects:

DSP - This library implements a set of basic digital signal processing (DSP) functions, such as the "dot product" operation key to convolution and digital filtering. The implementation uses the MMX, SSE and SSE2 in-

struction sets, where available, and a portable C version on all other CPUs.

Reed-Solomon - This library implements a family of Reed-Solomon encoders and decoders, including the CCSDS standard codecs used in the AO-40 format.

Viterbi Decoder - This library implements Viterbi decoders for two popular convolutional codes, including the $k=7$ $r=1/2$ code used in the AO-40 format. MMX, SSE, SSE2 and portable C versions are all provided.

Demodulation and Decoding Speed

Once acquisition occurs, real-time telemetry demodulation and decoding takes less than one percent of a 1 GHz Pentium III CPU running Linux. Acquisition takes more because of the brute-force search for carrier frequency, symbol timing and clock rate. To eliminate unnecessary CPU loading, the demodulator could be automatically disabled whenever when the spacecraft is below the horizon.

Conclusion

Powerful forward error correction techniques are ripe for amateur satellite use, especially on downlinks and on uplinks contaminated by radar interference. An encoder for the concatenated Reed-Solomon/convolutional code proposed here requires minimal resources, and can be easily implemented in the AO-40 IHU. On future satellites, an encoder could be easily integrated into the housekeeping software, or perhaps in a small dedicated microcontroller. When spacecraft CPU cycles are available, the cost of FEC is essentially nothing, but the benefits are enormous.

Credits

I'd like to thank the following people for their ideas, suggestions, data and other significant contributions to this project: Rick Hambly, W2GPS; Bob Brunega WB4APR; Jan King, W3GEY; Tom Clark, W3IWI; Peter Guelzow, DB2OS; James Miller, G3RUH; Stacey Mills, W4SM; Bob McGwier, N4HY; and Ron Parise, W3SIR.

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Telemetry

[continued from page 17]

AMSAT-UK Oscar Book Announced

AMSAT-UK announced the release of its new edition of "The Guide to Oscar Operating". This book, the mainstay of AMSAT-UK's beginners training manuals since 1975 and last rewritten in 1998, has undergone a major rewrite and now consists of 65 pages including colour photographs. But the price, five UK pounds plus postage (roughly US \$12.50 including overseas postage), has not changed. Richard G3RWL, Communication Officer of AMSAT-UK said, "We are keeping the price low so that beginners are able to obtain information cheaply."

The book is available by credit card from our website; follow the links from <http://www.uk.amsat.org>, by fax or mail to the Secretary:

JD Heck G3WGM
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Fax orders to +44 (0)1258 453959

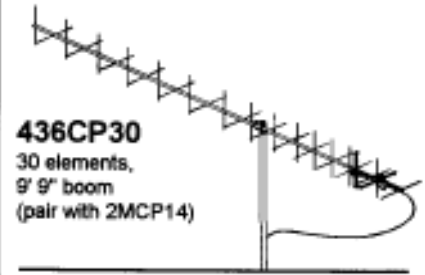
Orders can NOT be accepted by e-mail for security reasons.

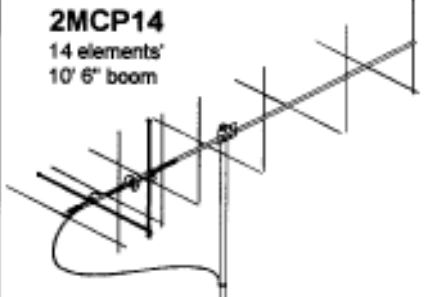
Actual prices: five pounds plus one pound postage in the UK but include two pounds postage in Europe, and three pounds postage for the rest of the world. (The minimum order is waived for the purchase of this book.) All profits go towards amateur satellite programs. ■

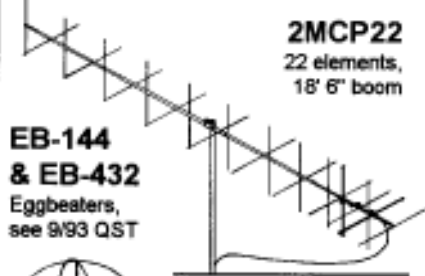
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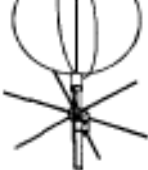
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Portable AO-40 Antenna System Available for Loan to DXpedition

by Wayne Estes, W9AE

In an effort to help DXpedition teams and individual traveling satellite operators to activate rare DXCC entities on AO40, I have assembled an "AO40 DXpedition antenna kit" which is available for loan. The complete antenna system packs in a 25"x25"x7" box that I am willing to ship to anyone in the United States who is willing to use it to activate a rare DXCC entity on AO40, then return the kit afterwards.

The antenna kit contains the following:

- 25"x25"x7" plywood box with handle and padlocks, suitable for air/sea travel;
- 2-foot G3RUH aluminum dish and patch feed for receiving 2401 MHz;
- Transystem AIDC3731 downconverter, modified for direct 12VDC power;
- Power inserter (if needed);
- 7x7 element circular polarized yagi for 435 MHz uplink;
- 27" folding wooden crossboom;
- Velbon DF-60 heavy duty camera tripod;
- 42 feet of 9913FX coax for the 435 MHz uplink;
- 42 feet of RG-6 coax for the downlink;
- SSB Electronics protector (prevents transmission into downconverter);
- Compass and protractor (for initial setup of azimuth and elevation);
- 40-foot headphone extension cord (for az/el tweaks while listening to the beacon);
- Drawstring bag (fill with rocks or sand to keep tripod from blowing over in wind);
- G6LVB "old tech" AO40 frequency calculator.

The antenna kit has been successfully used as a part of several portable operations, including one where it was shipped as airline luggage and used to score fourth place in the 2002 AMSAT Field Day competition. The package is rugged enough for travel, easy to assemble and disassemble, and performs well on AO40 when the squint is reasonable. Everything can be assembled with bare hands in about 10 minutes. There are no rotors, so the azimuth and elevation must be manually adjusted every 30-45 minutes during an AO40 pass.

To operate LEO satellites, a 3-element 2m yagi can be added to the kit. The yagi, crossboom extension, and coax cable add an additional 7 pounds to the kit, raising the total weight to 42 pounds. During Field Day 2002, W9AE made eight contacts on FO-20 and FO-29 with this setup. However, LEO satellite operation is very inconvenient without rotors, and reception of the Fuji satellites was marginal without a mast-mounted preamp for the 70cm downlink. The 3-element 2m yagi add-on would probably be entirely satisfactory for the FM satellites which have stronger downlinks.

The recommended transceiver for use with this antenna kit is a Yaesu FT-847, Kenwood TS-2000, or Icom IC-910H. Older satellite radios such as Yaesu FT-736R and

Icom IC-821 would work but their lower transmitting power is of marginal acceptability unless used with an external power amplifier. Most satellite enthusiasts interested in activating a rare entity on satellite will already own a "satellite" transceiver, but do not have Oscar-40 antennas that are easy to travel with. (W9AE does *not* have a spare satellite transceiver available for loan.)

Contact Wayne Estes W9AE at w9ae@amsat.org if you are interested in borrowing the antenna kit. If you know of someone who is interested in activating AO40 from a rare DXCC entity, please let them know that this antenna kit is available for loan. ■



"AO40 DXpedition Antenna Kit" and travel case (photo Wayne Estes, W9AE)

Launch Date Announced for SAFIR-M Amateur Radio Payload

AMSAT received a message from Oliver Amend DG6BCE and the German Amateur Radio Association announcing the planned launch of an amateur radio payload "SAFIR-M" aboard a German scientific satellite named "RUBIN-2". The launch is scheduled for 20th of December 2002 from Baikonour into an 650 km orbit with 65 degree inclination.

SAFIR-M is a project of a group called Arbeitskreis Amateurfunk und Telekommunikation in der Schule, or AATiS e.V. Its english translation means "Working Group for Amateur Radio and Telecommunications in Schools."

SAFIR-M was developed in close cooperation with the University of Applied Sciences in Pforzheim, Germany under the leadership of Henning Rech DF9IC and his team. The main purpose of the satellite is to give students easy access to space communications. It will have a downlink at 145.825 MHz with AX.25, 9k6 packet as well as an optional voice message beacon. The uplink is at 435.275 MHz (AX.25, 1k2), offering Mode B operation. The callsign will be DP0AIS.

SAFIR-M is designed as a "store and broadcast" system for APRS based messages, dedicated for the use of schools in combination with the existing WX-Net and planned buoy experiments in Germany. It extends German space educational activities to an European and global base.

Details on SAFIR-M can be found on <http://amend.gmxhome.de>. Information about AATiS e.V. is available under <http://www.aatis.de>. The SAFIR-M homepage is still in German, but work is underway to add the information in English.

[continues on page 28]

Five AMSAT Presidents Meet in Fort Worth



The 2002 Symposium gave the opportunity for a reunion of five AMSAT Presidents. Shown L-R are Robin Haighton, VE3FRH, current president of AMSAT-NA since, 2001; Keith Baker, KB1SF, 1999 - 2000; Bill Tynan, W3XO, 1991 - 1998; Tom Clark, W3IWI, 1980 - 1984; and Perry Klein, W3PK, 1969 - 1980.

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The 2003 IEEE International Symposium on Electromagnetic Compatibility Istanbul, Turkey, May 11-16, 2003 Special Session on Amateur Radio Service Concerns

World Radio 2003 will take place in Geneva in June and July 2003. There are several important issues for radio amateurs on the agenda most of them impose a threat from various interest groups on the frequencies allocated to the Amateur Radio Services. Within our countries we can see the trend to impose more and more restrictions on the Radio Amateurs.

Realizing the significance of the threat to Amateur Radio Services, the Organizing Committee of the 2003 IEEE International Symposium on EMC, has allocated a special session in this Symposium to deal with problems related to the Amateur Radio Services.

Many Radio Amateurs and many Amateur Radio Organizations are very busy working to minimize the loss and maximize the gain to Amateur Radio Services during the WARC 2003. The 2003 IEEE International Symposium on EMC, taking place on May 11 to 16, 2003, will be the LAST CHANCE before WARC 2003 to meet key persons from the international EMC and Radio community, researchers, regulators and others, exchange views and influence the decisions.

You are invited to provide a formal paper, informal paper or a presentation or take part in formal and informal meetings during this conference with those key persons and improve your knowledge, as well. For more details please refer to our web site at: www.ortra.com/emc2003 and click on the hyperlink "Radio Amateurs". ■

AM01601 IPS Emulator Available

Paul VP9MU announced that development and emulation software, called IPS, for the next generation of AMSAT Internal House-keeping processors has been made available on the AMSAT web page.

Paul described it as, "IPS is a powerful yet simple process control language. It is very stable and reliable. A custom processor code-

named theAm1601 is currently under development for AMSAT use. This processor is being specifically designed to be IPS friendly."

An Am1601 emulator program for Windows NT, and a general user version of IPS to run on the emulator are now available for download.

Paul reminded potential developers that, "The purpose of the emulator is to aid the design and development of the hardware Am1601, not to run "real-life" programs. IPS running on the emulator is considerably slower than it would be on a real hardware machine. That said, the emulator is a very useful tool for debugging purposes."

This software is being made available to the general public for peer review purposes, and is provided "as is" under the GNU license. This is a work in progress, ... please remember that!

The Programmers Reference for the Am1601 is available in both MS Word and .pdf formats on the AMSAT-NA web site.

You can find the emulator and documentation here: <http://www.amsat.org/amsat/projects/ips/Am1601.html>

General documentation on IPS and IPS-X can be found in the IPSDOS (ips.zip) file, which can be found here: <http://www.amsat.org/amsat/sats/ao40/ips.html>. ■

AO-40 QSO Party 24-25 January

Reinhard Sual, YB0KTQ announced the first AO-40 QSO Party scheduled to take place on-the-air on the weekend of 24-25 January, 2003. The objective is to encourage more and more amateur radio stations to enjoy two way communication via AO-40, especially when conditions are good on this satellite.

Rules Of Operation

1. All Rules from Local / International Organization have priority over these rules.
2. Any station can participate, as long as, it has its own facility (both uplink and downlink).
3. No relay / repeater use in any kind is permitted. One station is only valid for one entry. A station can be a single operator with his/her own call, or a group of operators with a club station call, providing only use ONE set of radio is used (multi-op with single radio).

4. Use only electronic Log-Sheet (a freeware logger is available at <http://www.qsl.net/kc4elo>)

6. Software for calculating the TX-RX frequency is available at <http://www.isibrno.cz/~kasal/AO-40Fqcalc.htm>.

Suggested Frequency

Downlink: S-band, USB

Uplink: U-band LSB OR L-band LSB (only one band per station is allowed during the event)

Mode: SSB Only

Keep +/- 10 kHz from MB always clear.

QSO Party Duration

This event will take place January 24 and January 25 2003, which is Orbit#1016 and #1017. Starting and ending MA is in accordance with the availability of the passband.

Award

A special certificate will be issued, for those who have a minimum 20 QSOs with different stations, and send their electronic logsheet via eMail, also sending SASE and US\$ 5 via post office. A special award will be given to the station with the most DXCC countries provided that they send their electronic logsheet via e-mail. The electronic log sheet in ASCII text, ADIF, or Microsoft Excel formats, should be sent to ReinhardSual@TheTempoGroup.Net

The closing date for electronic log-sheet submission is 31 January 2003.

Post Office Address

To get a special certificate send an SASE and US\$ 5 to:

Reinhard Sual – YB0KTQ
Pulo Gebang Permai G1/9
Jakarta Timur 13950
Indonesia

All information on this AO-40 QSO Party is available on Internet at <http://202.158.39.236/AO40QSOParty2003.asp>

This event is coordinated by YB0KTQ, and by no means related to any organization, locally or internationally. However, Reinhard has discussed the QSO Party with friends, especially among AO-40 enthusiasts from more than 15 countries, who support this event. ■

[continues on page 30]

President's Letter December 2002

Merry Christmas and a Happy New Year to everyone. Since I wrote the November Letter, a number of events have taken place which have had an impact on AMSAT. First, at the end of November the TRW amateur Radio Club in Los Angeles invited me to be the guest speaker at their awards night. Very generously they paid all the expenses, and I was able to talk about AMSAT and our new projects. One of my Power Point slides showed OSCAR 4 which was built at TRW in 1965. Several members of the Team that built that satellite were present at the awards night meeting.

Earlier this month the Amateur Radio on the International Space Station (ARISS) team held one of their semi-annual meetings at Goddard Space Flight Center (GSFC) near Washington D.C. with International Delegates from the US, Canada, Japan, Europe and Russia. The objective of this meeting was to review the progress being made with new Amateur Programs, to try and solve any problems, to co-ordinate future programs, and to see that they meet the IARU amateur requirements.

On this occasion the elections for ARISS officers took place and the results were as follows, Chairman - Frank Bauer KA3HDO, Vice Chairman Gaston Bertels ON4WF, Secretary Rosalie White WA1STO. Congratulations to all three.

The three day meeting was considered a success. Approval was given to Bob Bruninga to incorporate an APRS transceiver into a US Navy solar cell experiment which is to be launched in the middle of next year (2003) and which will be attached to ISS for one year. Details of Bob's PCSat2 may be found elsewhere on the web.

For those of you who wish to follow the events of ISS closely, you can subscribe to Sarex@amsat.org. This is easily done by sending a one line message to Majordomo@amsat.org the one line being, "subscribe sarex@amsat.org" (without the quotes).

During the Christmas shopping rush, it occurred to me that many of us often wish we were buying ourselves a suitable present! well now is your chance to do that and show that you are an AMSAT supporter - Why not become a donor to the AMSAT President's club? - get the Lapel pin and put it on your club jacket - they sure look good

[continues on page 30]

2002 Symposium Photo Highlights



(above) The satellite flea market and swap area.



(above) Martha Saragovitz shown tending the AMSAT Store. 2002 Symposium Proceedings are available by mail for \$20.00 + postage. Contact Martha at:

AMSAT
850 Sligo Avenue, Suite 600
Silver Spring, MD 20910-4703
Telephone 301-589-6062; Fax 301-608-3410

[President's Letter, continued from page 29]

at a club meeting! The President's Club donor form is now available on the AMSAT web page.

Once more may I wish a Happy Holiday to everyone.

73

Robin Haighton VE3FRH

President AMSAT ■

Telemetry

[continued from page 28]

ISS Expedition 5 Farewell

Subject: GOOD BYE!

DEAR FRIENDS! WE WERE SO HAPPY TO LIVE AND WORK SIX MONTHS ON BOARD OF ISS. WE WERE GLAD TO USE HAM RADIO TO HAVE PMS AND VOICE CONTACTS WITH YOU LIVING ON THE PLANET EARTH. IT WAS VERY NICE TO MEET IN AI OUR OLD FRIENDS WITH WHOM WE HAVE HAD COMMUNICATION WITH STATION MIR. APPRECIATED! IT WAS ALSO GREAT TO MEET NEW OPERATORS FROM BIG COUNTRIES AND SMALL AND UNUSUAL CORNERS OF OUR PLANET. ISS FAN CLUB HAS A LOT OF INFORMATION ABOUT ISS AND ARISS. GREETINGS FOR MEMBERS OF THE CLUB! WE WISH EVERYONE ALL THE BEST! WE WILL MISS YOU! 73!

CREW OF EXPEDITION 5 ISS VALERY KORZUN, PEGGY WHITSON, SERGEY TRESHEV. ■

2002 Symposium Photo Highlights



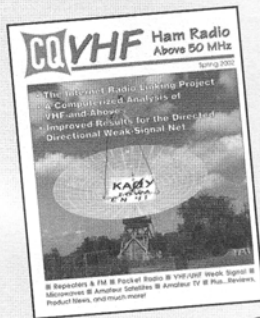
(top) Jerry Brown, K5OE, discusses his design for a K-Band Receiver for AO-40.

(center) Patch antenna for receiving AO-40 on display.



(left) L-R: Frank Bauer, KA3HDO, accepts a plaque noting his service and dedication to the ARISS program from Coy Day and Chris Imlay of the American Radio Relay League.

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Apogee View

[continued from page 3]

often light up in recognition.

So, in that sense, the return on our investment in ARISS and its predecessors has been nothing short of phenomenal. For, nowhere else has AMSAT and Amateur Radio been more visible to government regulators and to the public at large than through these projects. And nowhere else has there been a more convincing argument made to justify our continued, free access to the precious frequency spectrum we now enjoy than by providing the means for a middle-school student to personally ask an astronaut in orbit what it's *really* like to ride in space. To say that SAREX and ARISS have changed lives is an understatement.

Defending our frequencies from continued encroachment by well-heeled commercial interests must remain our top priority. I'm clinging to the slim hope that the public's recognition of the ARISS project will continue to be a powerful tool worth many, many millions of dollars to Amateur Radio in the very real "PR war" that's now being waged over our frequencies.

But, besides being a vehicle to justify the continued free access to our bands, the work now being done by our ARISS volunteers has resulted in a whole host of other, very powerful, life-changing events for hundreds, if not thousands of school children and their families. There is absolutely *no* doubt in my mind that the singularly distinctive accomplishments of the people working the ARISS project have also made the world just a little bit better place for the rest of us live in.

Keith Baker, KB1SF
Immediate Past President ■

Congratulations to Martha Saragovitz on your 25 years of service to AMSAT!

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